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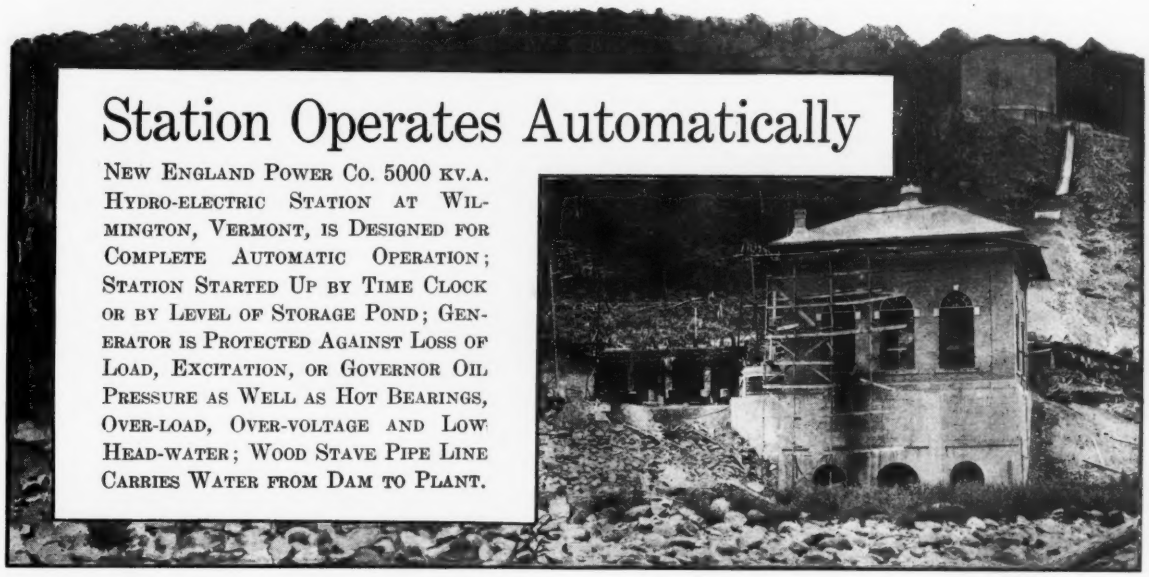


## Station Operates Automatically

NEW ENGLAND POWER CO. 5000 KV.A. HYDRO-ELECTRIC STATION AT WILMINGTON, VERMONT, IS DESIGNED FOR COMPLETE AUTOMATIC OPERATION; STATION STARTED UP BY TIME CLOCK OR BY LEVEL OF STORAGE POND; GENERATOR IS PROTECTED AGAINST LOSS OF LOAD, EXCITATION, OR GOVERNOR OIL PRESSURE AS WELL AS HOT BEARINGS, OVER-LOAD, OVER-VOLTAGE AND LOW HEAD-WATER; WOOD STAVE PIPE LINE CARRIES WATER FROM DAM TO PLANT.

UP ON the Deerfield River near Wilmington, Vt., the New England Power Co. has a 5000-kv.a. hydroelectric station which exhibits almost human intelligence through the arrangement of design which permits complete automatic operation. Besides picking up the load automatically, the generating unit is protected against loss of load, loss of excitation, loss of governor oil pressure, hot bearings, overload, over-voltage and low head water. In the case of low head water, overload, low oil pressure, or overspeed, the generator is tripped off, but comes on automatically as soon as conditions are normal.

While the details of securing this complete automatic operation are seemingly quite intricate, the governor mechanism and relays which control the sequence of operation are so well designed that no trouble has been experienced. In the case of this station, the question of reliability and freedom from minor troubles is especially important since the site is somewhat inaccessible, especially during the winter months. Since the amount of power available at this particular development of the Deerfield River is not of sufficient importance to warrant a station operated with the usual manual control, it was decided to build a station at this point which would utilize the resources and at the same time keep the operating costs at a minimum. After a careful consideration of the possibilities the present automatic station was installed.

During the first few months of its operation, it was thought best to maintain the regular quota of operating men because of the inaccessibility of the station should trouble occur. As time goes on and a thorough working test demonstrates how the plan will work out, it is expected that all of the operators will be withdrawn except an inspector who will reside near the plant.

### ARRANGED FOR MANUAL OR AUTOMATIC CONTROL

AS WILL be noted from the plan of the station, shown in Fig. 1, and several views of the operating details shown in succeeding figures, the station is arranged for manual, combination manual and automatic, or complete automatic operation. A 4-pole double throw knife switch determines whether the station is to operate manually or automatically. In the first position of this switch the control becomes manual and in the other position the control is thrown over to the automatic panel. In this automatic position the station will start up at a predetermined pond level or when a time clock closes the control circuit.

Assuming that all of the equipment is shut down and the station is under the control of the time clock, the action is as follows: As the time clock control contacts close, a master contactor picks up and energizes a circuit. A motor operated by this circuit shuts off the water pressure from the brakes and opens up the relief valve so that the brakes are released. At the same time the circuit energizes a small solenoid on the governor which admits oil pressure to the main piston of the governor, causing the gates of the wheel to open allowing the water wheel to come slowly up to speed. When the water wheel and generator are within 95 per cent of synchronous speed a centrifugal switch on the gen-

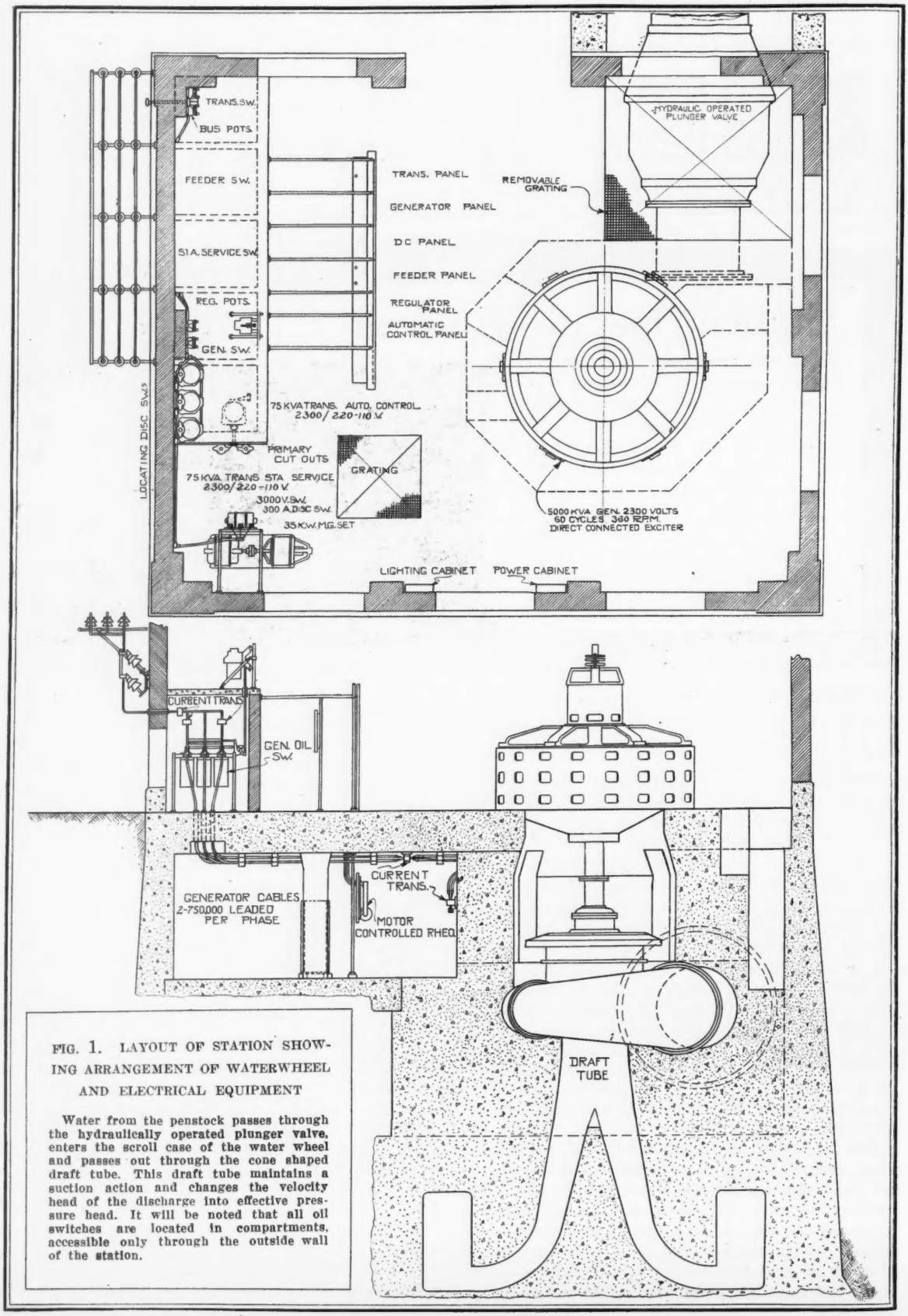



FIG. 1. LAYOUT OF STATION SHOWING ARRANGEMENT OF WATERWHEEL AND ELECTRICAL EQUIPMENT

Water from the penstock passes through the hydraulically operated plunger valve, enters the scroll case of the water wheel and passes out through the cone shaped draft tube. This draft tube maintains a suction action and changes the velocity head of the discharge into effective pressure head. It will be noted that all oil switches are located in compartments, accessible only through the outside wall of the station.

erator shaft closes which causes the generator oil switch to close, connecting the generator to the station bus.

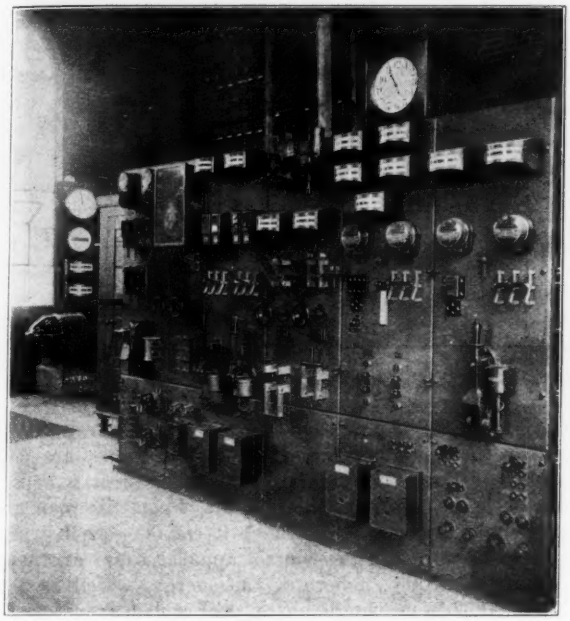


FIG. 2. AUTOMATIC SWITCHBOARD WITH DUPLICATE MANUAL EQUIPMENT

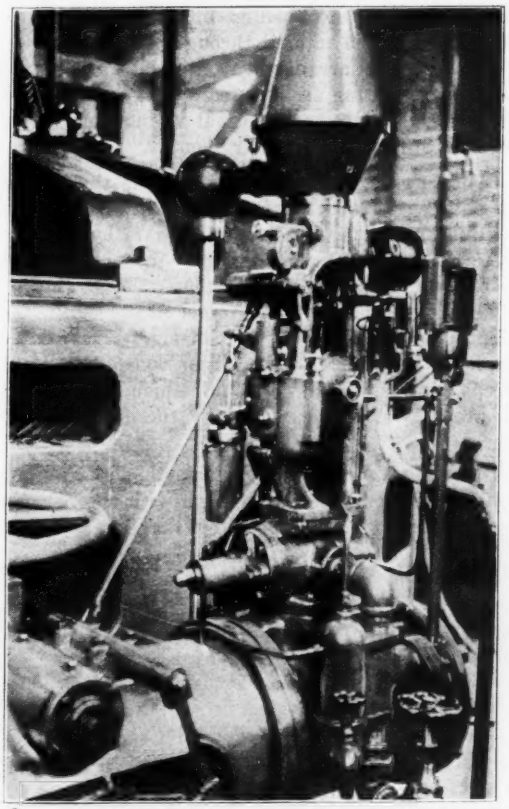


FIG. 3. GOVERNOR WHICH CONTROLS THE STARTING OF THE UNIT

As the generator switch closes, a small auxiliary switch makes contact and causes the field switch on the generator to close. This completes the operation of putting the generator on the line. The governor, however, continues to open the gates until some prearranged gate opening has been reached. In determining this gate opening, the amount of storage water available and the load which is demanded at that particular time are considered.

### Protective Features of Station

Probably the most interesting features in connection with this automatic operation are in the methods which have been devised to assure complete protection for all emergencies which might arise. As previously mentioned, the unit comes back on the line in case the

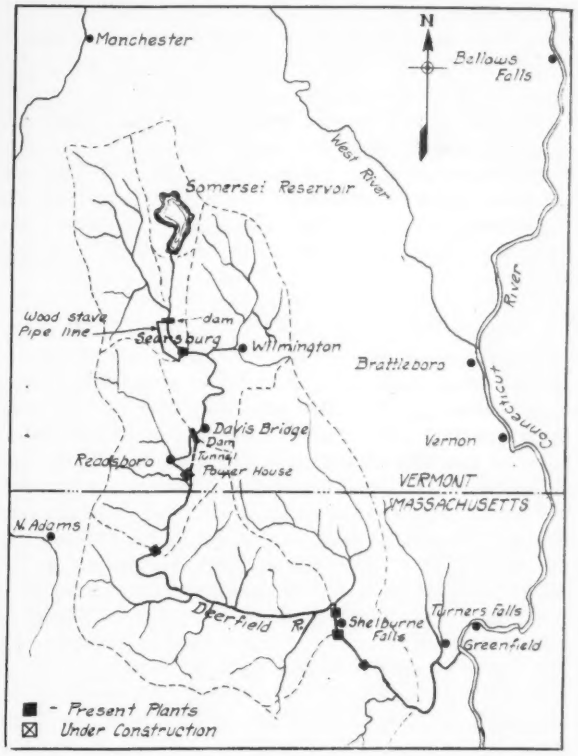



FIG. 4. LOCATION OF THE PLANT ON THE DEERFIELD RIVER

emergency condition is one of a temporary nature. In such cases as bearing trouble or loss of excitation, the generator is tripped off the line and remains off until hand reset relays are closed. In protecting against excess voltage, the arrangement is such that auxiliary relays connected to the Tirrill regulator cut auxiliary resistance into the exciter field should the excess voltage be too high for the regulator to handle. This auxiliary resistance throws the excess voltage into the zone which can be taken care of by the regulator equipment.

As originally laid out, if any of the protective features became operative the generator was not tripped off the line, except in the case of internal generator trouble, until the gate opening had been reduced sufficiently so that the speed of the generator under no load conditions would not be above normal. This prevented any racing due to suddenly dropping the generator load. After a trial this scheme was discarded on account of difficulty in getting proper relay selection between generator switch and the low side of the transformer switch.

FIG. 5. WOOD STAVE PIPE LINE UNDER CONSTRUCTION

In case of line trouble between this station and the high line connected to the rest of the system, the generator is protected by the overload trips. If, however, the line cannot be energized the automatic station will not attempt to come in again as the equipment is non-operative until the station bus is made alive from the system.

### Generator Starts as Induction Motor

It will be noted that the generating unit is thrown on the station bus when the speed is within 95 per cent of synchronous. In order to synchronize the incoming generator with the balance of the system, the generator actually operates as an induction motor until the field switch is closed. This interval is quite brief, probably not longer than one-tenth of a second, and since the New England Power Company's system is quite large it is not possible to detect any voltage fluctuation at the other stations when the automatic unit is thrown on the line. Upon shutting down, the governor solenoid circuit is opened by the time clock, thus causing the gates to close slowly. Upon reaching approximately 10 per cent gate opening the generator oil switch drops out and causes the generator field switch to open. When the gates reach the closed position the brake relief valve is closed and the brake applied.

Generating equipment in this station consists of a single 6200-hp. I. P. Morris vertical turbine driving a 5000-kv.a. 360 r.p.m. General Electric generator with direct connected exciter. The turbine gates are controlled by a Woodward governor. This unit is housed in the brick building, 33 by 40 ft. From the plan and sectional view shown in Fig. 1 it can be seen how the generator unit and the control apparatus are arranged. From the 2200-v. generator the energy is delivered to three 1667-kv.a., single-phase, self-cooled transformers which raise the voltage to 66,000, which is the voltage of the transmission system with which this station is tied up. All of the oil switches are located in compartments which have no opening into the building proper but which must be entered through the exterior wall of the station. This arrangement eliminates the possibility of damage resulting from defective oil switches such as might be caused by an abnormal voltage surge or from lightning during the summer months.

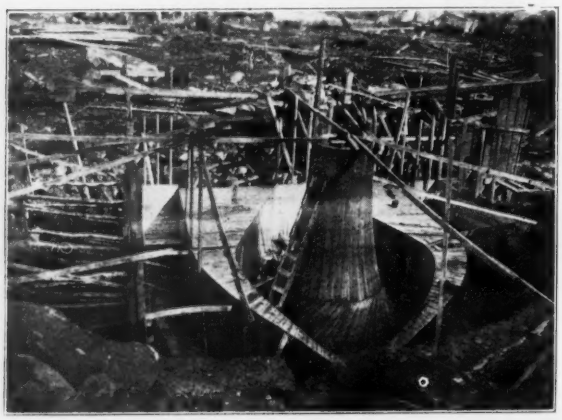


FIG. 6. CONCRETE FORMS FOR THE DRAFT TUBE

By referring to Fig. 4, which shows the location of this plant with respect to the other plants of the system. it will be noted that the automatic station is the next one to Somerset reservoir which is the controlling storage for the Deerfield river system. The drainage area above the Searsburg plant totals about 60 sq. mi. of which 30 mi. drains into the Somerset reservoir and is completely controlled. In addition to this drainage area there is an area of about 8 sq. mi. which is collected from two brooks which are crossed by the conduit from the dam.

Diversion works consist of an earth, sluiced core, dam about 450 ft. long and 50 ft. high with a concrete spillway 140 ft. long. In building the dam some 55,000 cu. yd. of boulder clay was used for fill, which was obtained from a pit about a half mile from the site of the dam. In Fig. 8 is shown a view of the Somerset reservoir dam during the course of construction. The dam at Searsburg was constructed in a similar manner by what is known as the modified hydraulic fill method. As will be noted from this view, the earth is hauled out on a trestle, dumped and then sluiced to the center of the fill. In this method the trestle is moved up in a series of steps as the work progresses. Such a dam consists of a very compact earth core while the outer portions are made up of coarser material.

Although the height of the dam is only 50 ft., the total head of the plant down stream is 210 ft. The crest is 7 ft. above high water with the flash boards, which are 6 ft. in height, in place. These flash boards

are made up of panels and are held on the spillway by means of solid pins spaced 2 ft. center to center.

Water from the dam passes through an intake rack made up of 3-in. by ¼-in. bars spaced edgeways on 1½-in. centers, to the intake well. This well is just behind the head gates of the wood stave piping. Both the head gates and the sluice gates were furnished by the Coffin Valve Co.

From the pond which is formed and which is sufficiently large to equalize daily flow the water is led through about 18,000 ft. of wood stave conduit 8 ft. in diameter. This wood stave pipe line is supported on pre-cast concrete cradles set 8 ft. center to center. Where it has been necessary to make sharp bends in the line this has been done by using special plate angles.

Douglas fir to the amount of 1,600,000 board feet were used in the construction of the conduit which was furnished and erected by the Continental Pipe and Mfg. Co. Fifty-five freight cars were required to transport the lumber from the state of Washington and in addition 600 T. of ¾-in. bands and 75 T. of shoes were used in its erection.

Special features in connection with the erection of the conduit may be of interest. In general it follows the natural contour of the valley with an average slope of 1 ft. per 1000 ft. The special bends which were used allowed a deflection of alinement of 20 deg. per 5 ft. length of pipe, whereas the maximum with the wood stave is only 1 deg. per 5 ft. length.

In its winding path from the dam to the penstock the conduit crosses the two brooks previously mentioned. The first, Bond Brook, is crossed on a trestle, provision being made for admitting the water from the brook by a 24-in. pipe stave line. At the second or Medbury brook, the conduit dips about 65 ft. and rises again to the former level forming an inverted siphon. Water from this brook is also diverted into the pipe line.

From the junction of the wood stave conduit and the penstock a short branch conduit leads to a Johnson differential surge tank designed to prevent spilling of water in case full load on the generator is thrown off suddenly or to permit an instantaneous load increase corresponding to 150 second ft. The superstructure of this surge tank is of steel, furnished and erected by the Chicago Bridge and Iron Works. The surge tank is

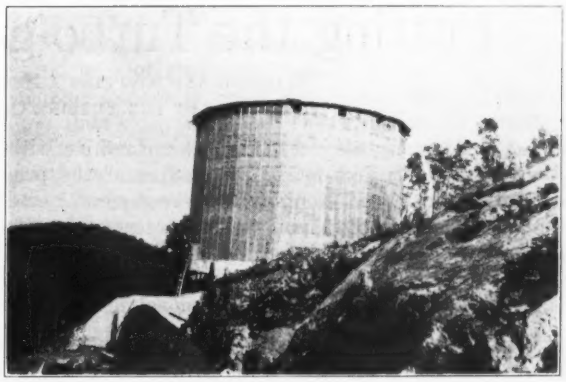


FIG. 7. SURGE TANK IS OF STEEL SHEATHED WITH WOOD

50 ft. in diameter, 35 ft. high and is sheathed with wood and paper.

Leading from the junction of the wood stave pipe line and the conduit connection to the surge tank, a 6 ft. 6 in. diameter plate steel penstock carries the water to the scroll chamber of the turbine. This penstock line is about 500 ft. long and is made up of 5/16-in. plate at the upper section and 9/16-in. plate for the lower half of the line. This pipe was furnished by the Lancaster Iron Works.

At the lower end of the penstock there is a Wellman, Seaver, Morgan hydraulically operated balanced plunger valve by means of which the water can be shut off from the turbine scroll.

After the water passes through the Johnson valve it enters the scroll case on the I. P. Morris turbine and then passes out through a draft tube of peculiar shape, as will be noted from the sectional view of the station in Fig. 1 and a view of the concrete form used in the construction of this tube, as shown in Fig. 6.

In the preparation of this article we are indebted to A. C. Eaton, hydraulic engineer, C. R. Bliss, who was resident engineer on the Searsburg plant, and E. B. Collins, assistant electrical engineer, all of whom are with the Power Construction Co. The Power Construction Co. is the construction division of the New England Power Co., with headquarters at Worcester, Mass. The Aberthaw Construction Co. of Boston was in charge of all excavation and concrete work and general construction.

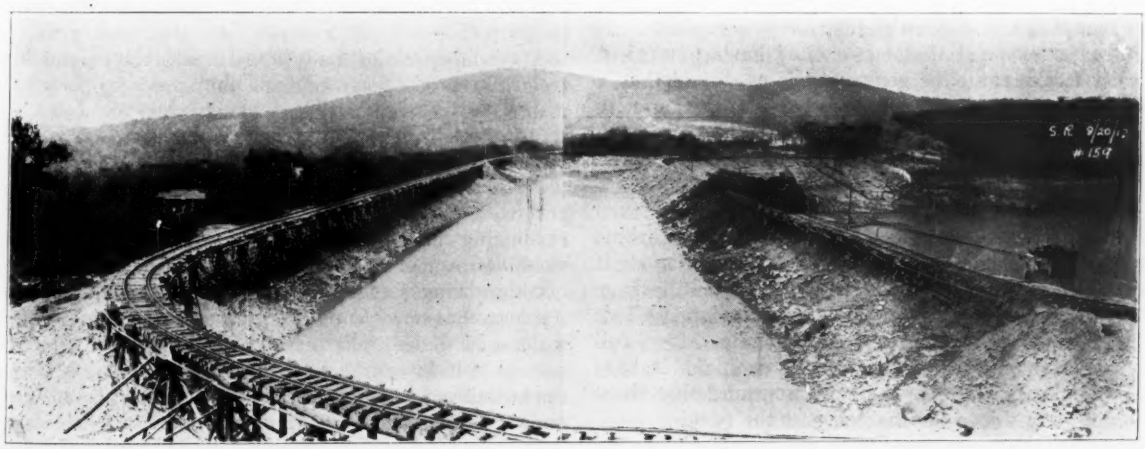
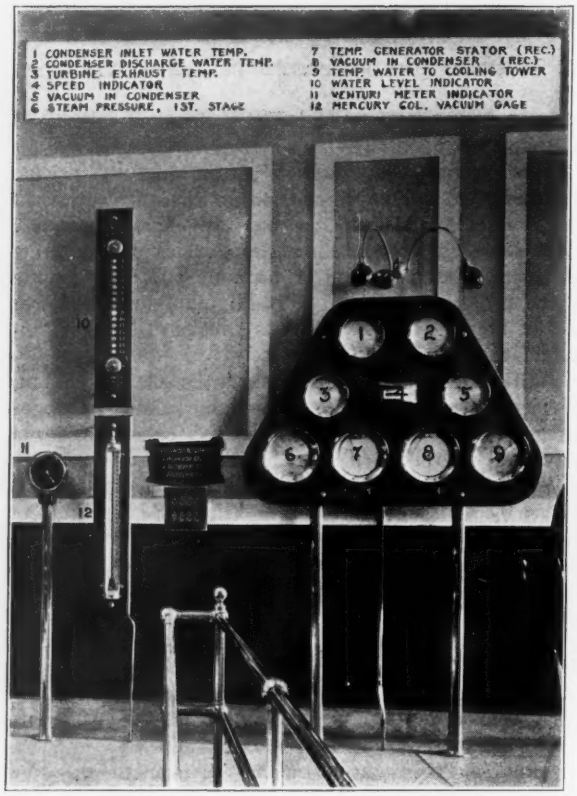


FIG. 8. SOMERSET DAM UNDER CONSTRUCTION—A SIMILAR SCHEME WAS EMPLOYED IN BUILDING THE SEARSBURG DAM

# Putting the Turbo-generator on the Line

STARTING AND STOPPING A STEAM TURBINE IS THE MOST IMPORTANT PART OF THE TURBINE OPERATOR'S JOB. BY H. G. ROBERTS

AS A good many engineers are yet unfamiliar with this type of prime mover, an outline of the procedure of starting and stopping a turbo-generator and getting it on and off the line may be of interest. In this instance, it will be assumed that the plant consists of two or more medium-sized Curtis turbines with their auxiliaries—jet condensers, centrifugal removal pumps, and


1 CONDENSER INLET WATER TEMP.
2 CONDENSER DISCHARGE WATER TEMP.
3 TURBINE EXHAUST TEMP.
4 SPEED INDICATOR
5 VACUUM IN CONDENSER
6 STEAM PRESSURE, 1ST. STAGE
7 TEMP. GENERATOR STATOR (REC.)
8 VACUUM IN CONDENSER (REC.)
9 TEMP. WATER TO COOLING TOWER
10 WATER LEVEL INDICATOR
11 VENTURI METER INDICATOR
12 MERCURY COL. VACUUM GAGE

THE TURBINE GAGE BOARD IS THE CENTER OF IMPORTANCE DURING THE INTERVAL OF STARTING

dry-vacuum pumps—such a plant being typical of a good many of the modern industrial power plants. It will also be assumed that one exciter having sufficient capacity to excite all the generators is used, and that it and a voltage regulator are already in operation with other machines; so that, in this case, there will be no exciter to start. The different operations will be carried out in the following order:

1. Turn cooling water on the bearings and turn steam into the packing seals. (This make of turbine uses carbon packing and a steam seal on the shaft where it passes through the casing to prevent leakage of air into it, which would lower the vacuum.) This sealing steam should be adjusted again after full vacuum is on, so that there will be a slight leakage from the glands, which will be an assurance that there is no air leaking into the turbine past the packing.

2. Start the centrifugal removal pump on the jet condenser. This may be driven by either a motor or a small steam turbine and is used to discharge the water that is drawn into the condenser by suction. Its action is not identical with that of the circulating pump used with surface condensers, as without the aid of the dry-vacuum pump to handle the air and non-condensable vapors, the vacuum in the condenser will soon be destroyed and stop the inflow of water.

3. Start the dry-vacuum pump. This may be one of several different types—rotative, hurling-water, steam ejector, etc. As the vacuum rises and water is drawn into the condenser, watch the gage glass and see that the water comes up to the proper height. Adjust the suction valve if necessary.

4. When normal vacuum is obtained, see that the casing drains are open, start the turbine revolving slowly and, unless needed in a hurry, let it run slowly for a while until thoroughly warmed up. The larger the machine, the longer will be the time required for this. In warming up, it is better to start it rolling over slowly right from the beginning, as in this way all parts are heated alike and there is less danger of distortion of the rotor from unequal expansion. While the turbine is warming up, do any hand oiling that is required about the valve gear, governor transmission, etc., and see that water and oil are flowing freely at the bearings. The drains may be partly closed now and shut off entirely before full speed is reached.

When warmed up, bring it up to speed gradually, though with continuous acceleration, and watch closely for vibration. Some turbines have a tendency to vibrate at some certain speed and, if allowed to run at this speed, the vibration will rapidly grow worse, as the effect is cumulative; so as this is approached give the turbine a little extra steam to get it through this speed as quickly as possible. While it is speeding up, put field current on the generator by closing the generator-field switch, so that the speed indicator will be operative and will indicate the speed. Also see that the proper oil pressures are being built up by the oil pump—approximately 15 lb. for the bearings and 75 lb. for the pilot valve and hydraulic operating cylinder. (One type of Curtis turbine uses steam in the operating cylinder instead of oil.) Watch the speed indicator and as normal speed is reached, see that the governor comes into operation and closes nozzle valves and controls the speed. If it controls the speed properly, the throttle valve may now be opened wide.

### PUTTING GENERATOR ON LINE

5. Now go to the switchboard and adjust the generator voltage to normal, put in a "running" synchronizing plug on a panel of one of the running machines, and a "starting" plug on the panel of the machine being started. The synchronism indicator, being now connected to the starting and running machine, will indicate their phase and speed relations. The generators are brought in step by remote control from the switchboard, a reversing switch operated by a "push and pull" button being used to control a little series motor on the turbine governor, which may be run in either direction so as to increase or decrease the tension

of an auxiliary spring connected to the governor. Unless one has had a good deal of experience in synchonizing and is quite skillful, he should be careful to adjust the speed of the incoming machine so that the pointer of the synchroscope is revolving quite slowly before attempting to close the main switch. It is considered best practice to close the generator switch just as the pointer is reaching the "in phase" position going in the direction of "fast." If the switch is remotely controlled, make allowance for the time element of the closing mechanism.

6. As soon as the generator switch is closed, turn the generator-field rheostat to its normal running position—generally, in the "all out" position—and remove the synchronizing plugs from their receptacles. The ammeters of this machine may now indicate considerable current, but it is all wattless current, as the indicating wattmeter will indicate zero. Load cannot be put on an alternating-current generator, running in parallel with other machines, by increasing its excitation, as this will only cause it to furnish a greater part of the wattless current of the system or increase the cross-current between machines. (It may be well to note here that increasing the excitation of one alternator above that of another, in parallel with it, will *not* cause a wattless circulating current between generators until the power factor of the lower-excited machine becomes *leading*.) The generator is made to take its share of the load by increasing the speed of the turbine. This is done by the same remote control of the governor as was used in synchronizing.

Watch the indicating wattmeter and apply the load somewhat gradually. Unless full capacity is needed in a hurry it is advisable to apply the load in steps, in the intervals noting whether or not the turbine is acting normally. Too sudden application of full load may cause the turbine to pull over water from the boilers or may cause vibration. In adjusting the division of load between generators, also observe the indications of frequency meters. It may be that instead of speeding up a machine to add load to it, slowing down of some other machine that is "hogging" the load would be the proper procedure in order to maintain the normal frequency of the system.

Having put load on the turbine, it is now in normal operation, and attention should be directed to indications of pressure and vacuum gages, oil pressure gages, bearing temperatures, flow of water and oil at bearings, etc. The bearings of a turbine, especially of the smaller sizes, may run considerably warmer than the bearings of a reciprocating engine, and no alarm need be felt if the hand can be held on a bearing for only a very short time. Turbine bearing temperatures may run up, in some cases, to 160 or even 175 deg. F. and give no trouble. Temperatures around 130 or 140 deg. F. may be considered normal, though larger, slower-speed turbines may run cooler.

Turbine auxiliaries require more attention than the turbine itself and close watch on the condensing equipment should be maintained and the vacuum kept up to the highest obtainable. While there is little gain in striving for higher than 26 in. of vacuum with a reciprocating engine, the turbine has the ability to use to advantage the highest attainable vacuum, the gain in economy being greater with an increase of vacuum from 28 to 29 in. than with an increase from 27 to 28 in. Very slight air leaks into the condenser will materially lower the vacuum and all joints between turbine and condenser should be kept absolutely tight.

Where there is considerable variation in the load from time to time, it may be necessary occasionally to readjust the division of load between machines, as different turbines may have slightly different speed-regulating characteristics. While of course one should keep a fairly close watch on a turbine plant, it requires far less attention than a reciprocating-engine plant, as there is practically no hand oiling to do, no bearings to be continually keying up, and no packing to do. One's time is devoted mainly to the observation of pressure, vacuum, and temperature indications, the flow of oil at bearings, etc.

### Shutting Down Turbine

Take the load off by transferring it to other machines. This is accomplished by remote control of the governor adjustment from the board, slowing down the turbine until the indicating wattmeter indicates zero. The load is now off the machine, but as it necessarily runs at the same speed as the other machines and has the same excitation, it still supplies its share of the wattless current of the system, as indicated by the ammeters. Now turn the generator-field rheostat "in" until the ammeters indicate zero, or nearly so, and trip the main oil switch. Immediately turn in all the rheostat resistance in order to reduce the field current to be broken to a minimum and open the field switch. (If desired, the field may be left on until the machine stops, but should not be left on while it is not running as it will cause heating.)

2. Shut down the turbine and the dry-vacuum pump, shut off the steam seals on the turbine, and after the vacuum is entirely off, shut down the motor driving the removal pump on the jet condenser. Open the drains on the turbine casing and, after the machine has come to a standstill, shut off the bearing cooling water.

Occasionally test the emergency governor, or safety stop, by overspeeding the turbine when shutting down. At about 10 per cent above normal speed, the emergency governor should operate to trip the throttle valve and close it. It is very important to keep this device in working order to prevent a possible runaway in case the main governor should become inoperative from any cause.

In the foregoing, it was assumed that other machines and an exciter were already in operation, which would be the normal conditions for starting a turbine in a plant that is in continuous service and which contains two or more machines, one of which may be shut down part of the time. In the case of a plant that is not in continuous service, or for any reason an entirely new start has to be made, the procedure of putting a turbine into service will be somewhat different.

If the removal pump on the jet condenser is motor driven, it cannot be started until after the turbine and generator are in operation to furnish current for it, so the turbine will necessarily have to be started non-condensing and the vacuum put on afterwards by using forced injection.

Generally the exciter is motor-driven also and a spare steam-driven unit used just for starting. After the alternating current voltage has been raised to normal, the motor-driven exciter is then started and paralleled

with the steam-driven unit and the latter then cut out and shut down.

Next, the Tirrill regulator is put in service. By means of the exciter-field rheostat, raise the alternating-current voltage to slightly above normal, or until the relay contacts on the regulator open. Then close the rheostat shunt circuit switch on the regulator and turn the exciter-field rheostat "in" to some predetermined marked point, when the regulator will begin operation. Conditions are now as first assumed and additional machines may be started in the usual way.

No mention has been made here of an auxiliary oil pump that is generally used with turbines during the starting and stopping periods, as the Curtis turbine uses this extra pump only in the larger sizes. In the case of any turbine so equipped, this pump must be started before the turbine is started and kept in operation until the regular oil pump is running fast enough to maintain the oil pressure. It is started again when shutting down and kept going until the turbine comes to a stop.

Westinghouse and Allis-Chalmers turbines use a water seal instead of a steam seal to prevent leakage of air into the turbine. This consists of a little centrifugal-pump impeller on the shaft, which, when supplied with water at a low pressure, maintains sufficient water pressure in an annular casing surrounding its periphery to prevent air from leaking past it. Obviously, this does not come into operation until considerable speed is reached, making it necessary, with a turbine having this method of packing the shaft, to start non-condensing. After sufficient speed has been reached to establish the water seal, the sealing water is turned on and, in the case of a jet condenser, forced injection is used until the vacuum is obtained, after which, the condensing water is drawn in by suction in the normal way. These turbines use lower oil pressures for the bearings and oil relay than the Curtis turbine uses.

# First Installation of a Ruths Accumulator in Germany

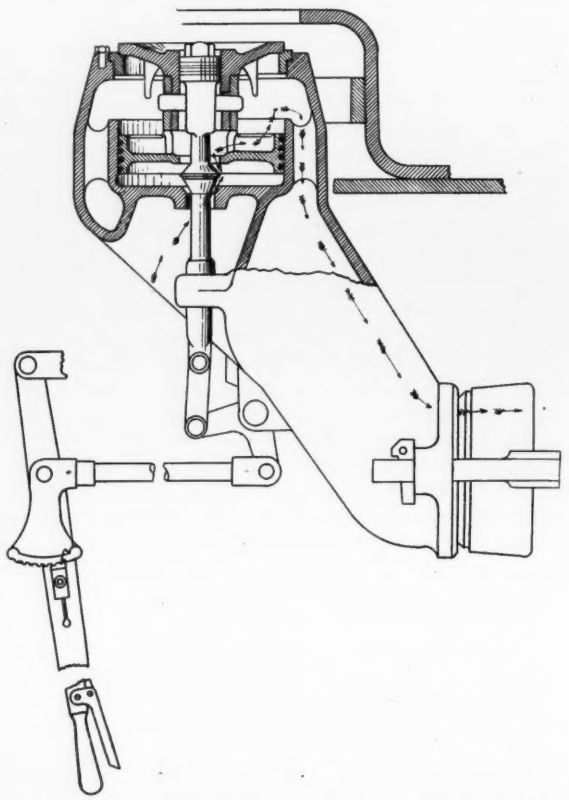
By J. H. Blakey

SOME details of installations of Ruths accumulator in Sweden, where it originated, appeared in Power Plant Engineering for March 1, 1922. In France it is being used at the Creusot plants, and in Germany the Lauchhammer establishments have recently adopted this method. The last named installation is described in Stahl und Eisen, in which M. Stein gives a detailed cost sheet of the boiler equipment both before and after the installation of the accumulators. The Lauchhammer power station serves an extensive system, feeding a number of metallurgical plants, the power required reaching 20,000 kw. (26,800 hp.) on the average at peak load. The boilers, 28 in number, are heated by lignite and run at an average pressure of 200 lb. per sq. in. The constant variation in the consumption of steam made it difficult to keep up the efficiency of the boilers, which was not more than 66 per cent on the average. Two turbo-alternators are included in the new installation, one of 12,500 kw., fed by steam from the boilers, and the other of 2500 kw., for emergency use, getting steam from two accumulators of 350 cubic meters (12,355 cu. ft.) capacity. The high pressure and low pressure stages of the turbine work alternately; at one time the steam from the high pressure stage is sent to the accumulators, at another time steam from the accumulators is fed to the low pressure stage.

Comparative cost sheets show that the consumption of coal per kilowatt-hour has been lowered from 3.54 to 3.09 kilograms (5.8 to 5.06 lb. per hp.-hr.) which amounts to 57,000 T. a year.

# Improved Throttle Valve

WITH certain modifications the improved throttle valve, shown in the illustration, that is much used —and liked—on the Pennsylvania Railroad, might be well adapted to stationary practice. Naturally, there is a quadrant and lever, an essential feature, as it enables the valve to be opened just to the desired amount, and held at that point, irrespective of any vibration. As will be seen, the idea is to provide a safe and sure opening for starting and for drifting; only enough steam being admitted to the cylinders to blow through and warm them up in starting, and to keep up a slow piston speed in drifting.



TWO VALVE SEATS OF DIFFERENT AREAS ARE INCORPORATED IN THIS THROTTLE VALVE

Pulling out the throttle lever one or two notches, only answers for slow-speed drifting; then, for starting and high-speed drifting (after all, a comparative term). It is only at the middle notch of the quadrant that the main valve commences to open; up to that point all the steam that can pass from steam space to dry pipe must be only that which the under or starting valve lets through, as indicated by the arrows.

# Heat Balance Obtained by Special Turbine

COMBINED MIXED FLOW AND BLEEDER TYPE UNIT FURNISHES POWER AND STEAM AT REDUCED PRESSURE TO TEXTILE MILL

INDUSTRIAL PLANTS often make demands for power that are difficult to meet economically. Many textile mills are of this type as will be understood when it is considered that their operations of finishing, dyeing, bleaching, printing, etc., create a widely variable demand for steam, hot water and power. To meet these demands and still hold a heat balance there has been developed a combined mixed flow and bleeder type of turbine.

At Norwich, Conn., is located a mill of the U. S. Finishing Co., where prior to 1910, power was developed partly by water and partly by several engine driven units. At this mill, as at many others in the New England states, the problem of inadequate water power had arisen.

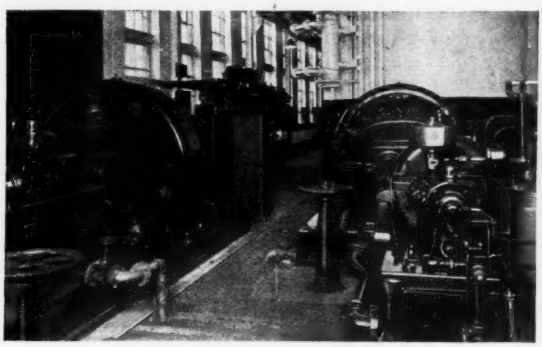


FIG. 1. TWO 1000 KW. NON-CONDENSING GEARED UNITS WERE INSTALLED

This condition is often brought about due to a mill outgrowing the water power available, a decrease in stream flow, or the stream flow may become variable or uncertain. At Norwich it was a case of shortage of water power and an increase in power requirements.

The problem then was to select such units as would meet economically variations in exhaust steam requirements, variations in power requirements, variations in hot water requirements, and variations in the amount of power available from water power. These numerous variables, often varying from hour to hour due to the character of the cloth being finished, made it extremely difficult to strike a heat balance with a straight non-condensing turbine alone or one condensing turbine and one non-condensing.

In 1910 the need for both heat and power made it necessary to install a new turbine driven unit to run non-condensing and to exhaust against a back pressure of 8 to 10 lb. The exhaust was used in processes, in many of which live steam had previously been employed. The unit selected was a geared turbine driven direct current generator, rated at 400 kw. After 12 yr. of practically continuous operation, often at overloads of 25 to 30 per cent, the power demand made necessary a still further increase in generating capacity.

Careful study of the requirements led to the removal of the original 400-kw. unit and the installation of three new geared turbine driven direct current generators, rated at 1000 kw. each. Two of these are non-condensing machines like the one originally installed and the third a special combined mixed flow and bleeder turbine driven set so designed as to be operated in the following ways: as a straight condensing turbine; as a back pressure turbine; as a bleeder turbine, that is, expanding part of the steam to the condenser and exhausting the remainder to the low pressure system; as a mixed flow turbine; and as a low-pressure turbine receiving low-pressure steam only.

In Fig. 1 is shown the installation of the two non-condensing units and in Fig. 2 is illustrated the valve

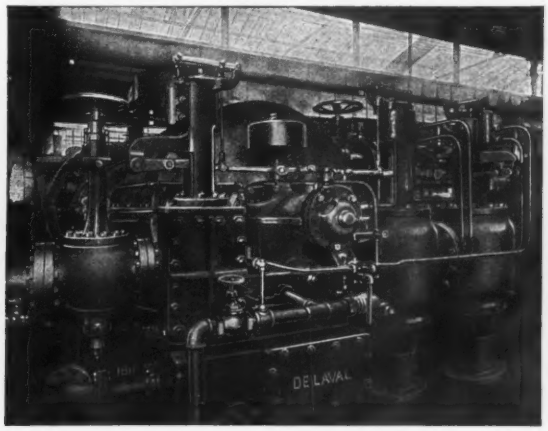



FIG. 2. THREE VALVES CONTROL THE COMBINED MIXED FLOW AND BLEEDER UNIT

and control mechanism of the combined mixed flow and bleeder type unit. This latter unit will receive steam from the low pressure line when there is a surplus of low-pressure steam from the other units, or will deliver steam to this line when there is a deficiency of steam for heating and process purposes. The change from one condition of operation to another is made automatically in response to the pressure existing in the low-pressure steam line.

In Fig. 3 is shown a diagram of the valve gear of the combined bleeder and mixed flow unit. Figure 4 is a cross section of the same unit. The speed governor controls a high-pressure valve in the high-pressure steam inlet and a low-pressure valve "b" in the low-pressure connection. The valve gear is so adjusted that the high-pressure valve does not open until the low-pressure valve is open full and is closed before the low-pressure valve begins to close. A third valve, "a," controlled by the pressure in the low-pressure piping is located in the connection from the low-pressure line to the low-pressure stages of the turbine.

Steam is normally bled from the turbine at "A" to the low-pressure steam system, except when the pressure in the latter exceeds a certain value, when the pressure control valve "a" opens and steam is admitted to the governor controlled valve "b," leading to the low-pressure stages of the turbine at "B." If there is an excess of low-pressure steam, the speed of the turbine may rise until the high-pressure steam is entirely cut off

by the governor, and if there is then still more low-pressure steam available than is needed to carry the load on the turbine, the governor will proceed to close the low-pressure valve. Any further excess of low-pressure steam will, of course, escape through the back pressure valve of the low-pressure system.

All three control valves are actuated by oil pressure through pilot valves. Two gear oil pumps are direct connected to the turbine shaft. These pumps furnish

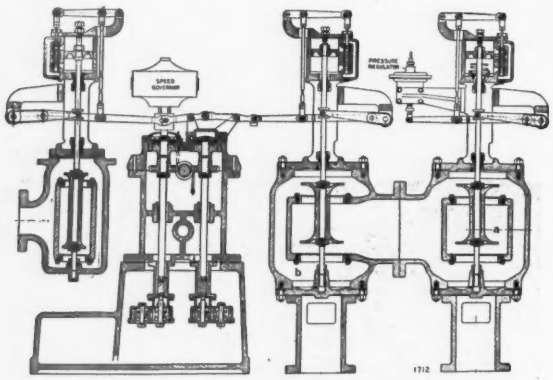


FIG. 3. DIAGRAM SHOWING GOVERNOR AND PRESSURE CONTROL OF COMBINED MIXED FLOW AND BLEEDER UNIT

oil both for the control valves and for lubrication purposes.

Day and Zimmerman, construction and consulting engineers, in collaboration with the engineers of the U. S. Finishing Co., worked out the design of this plant as outlined above.

# Oil Fuel for Steam Generation

POINTS TO BE CONSIDERED WHEN CONTEMPLATING CHANGE FROM SOLID FUEL TO OIL. BY C. H. S. TUPHOLME

FROM whatever point of view one approaches the subject, there can be no disputing the fact that the introduction of petroleum and its products into commercial processes constitutes one of the great developments in the history of industry. The existence of the mineral hydrocarbons in liquid form has long been known, but it is only within recent years that the use of petroleum has become general. Until very recently, the principal use of petroleum was for illuminating purposes; but the introduction of the internal combustion engine has so increased the demand that the supply has been unable to keep up with it. Controlled by a number of powerful corporations or trusts, this shortage in supply has resulted in high prices and the establishment of huge fortunes; but it is hoped that in the course of time new sources of supply will be found, and that prices will come back to a more normal figure.

At the present time, the principal sources of oil supply are the United States, India, Russia, Mexico, Roumania, Dutch East Indies, and Galicia. It will be seen, therefore, that for most parts of the world oil has to be brought a great distance before it can be used, and that this cost of carriage, handling, and storage will make it vastly more expensive than in the countries where the supply is obtained. Further, it is a noteworthy fact that those countries in which oil is most difficult to obtain are usually those where nature has been exceptionally bountiful in her supply of coal.

Utilizing oil for the production of steam in a country where oil is dear and coal cheap is a totally different problem from that of using oil close to the source of supply. This is a point constantly overlooked by the casual observer, but it is one of supreme importance in the determination of the plant to be used for the purpose.

In the oil fields, economy of fuel is of little account—any cheap kind of burner will suffice; whereas in England, where coal is cheap and oil dear, only the highest and most economical type of apparatus can have the slightest chance of success. At the present time, and with oil at its present price, I have no hesitation in saying that no advantage can be gained by using oil in the place of coal in England if the cost of fuel is the only consideration to be taken into account.

Apart from the question of cost of fuel, the utilization of oil for fuel present other advantages in that it requires far less labor to look after it, which in many cases is a very important consideration. Once set going, an oil-fuel installation will run for weeks with the

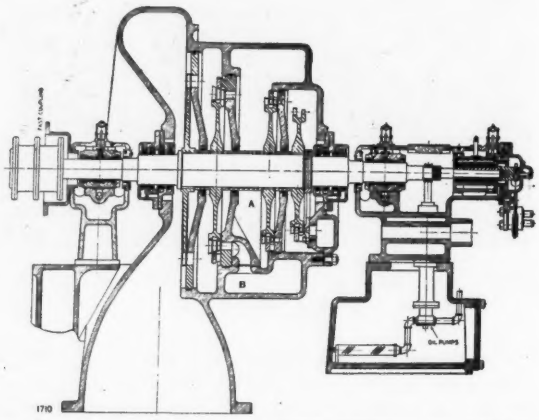


FIG. 4. DIAGRAM SHOWING CROSS SECTION OF COMBINED MIXED FLOW AND BLEEDER UNIT

minimum of attention—there are no ashes to clear away, and if working right there is no soot nor smoke.

While it is true that oil cannot compete with coal in the vicinity of a coal-pit, it must be remembered that coal is at an equal disadvantage on the oil fields, and further, that there are many places which have neither a supply of coal nor oil. It is in such places that the rival merits of the two classes of fuel will have to be fought out, and it is encouraging to see the amount of attention that is being given to the study of the economical combustion of oil fuel for this purpose. Steam users all over the world are full alive to the importance of the question, as the number of inquiries for oil-fired boilers is ample evidence. To burn oil in a steam boiler is a comparatively simple process, but to get the maximum heat value out of the oil is a much more difficult matter. In the oil fields, where economy of fuel is of little or no account, a very simple device costing only a few dollars will suffice; but if a really efficient plant is required, it may cost hundreds of dollars.

At present, the method universally adopted of burning oil is to introduce the oil in fine spray into the furnace, and the finer the spray the better are the results

obtained. This process of converting the liquid oil into spray is technically known as "atomizing," and many ingenious burners have been invented for this purpose. The more perfectly the oil is atomized the more readily can it be burnt, and the function of the burner is to atomize the oil into the finest spray possible.

Although the number of burners is numerous, they all work upon one of three methods—that is to say, the atomization is effected by steam, compressed air, or pressure. Apart from the atomization of the oil, it is held by some that further advantage is to be obtained by some process of "gasification," and experiments are now being tried in which the atomized spray is gasified in a more scientific way than is usual with the present appliances on the market. Steam burners atomize the oil, mixing steam with it and forcing it in the shape of a fine spray into the furnace; compressed air burners act on a similar principle, but air is used instead of steam. Pressure burners are independent of either steam or compressed air. The oil is fed under a pressure varying from 40 to 150 lb. to the burners, from which it escapes through a very small hole in the shape of a fine spray.

Each of these systems possesses certain advantages and practically equally efficient results can be obtained by any of them. The steam system has the merit of simplicity, but it has the disadvantage in the matter of lighting up in the case of a single boiler when there is no supplementary supply of steam. This difficulty is overcome by lighting a fire of wood or coal in the boiler until there is sufficient steam to operate the burner.

Steam required to atomize the oil usually amounts to about 8 to 12 per cent of the total steam generated, and as this amount of steam is lost, it must be made up by feeding the boiler with water. When a good supply of fresh water is not obtainable this is a serious disadvantage, consequently the system is not recommended on board ship.

Further disadvantage of the steam system is that it will not burn oil containing an appreciable amount of water, and for this reason it is desirable only to fit where it is possible to have large settling tanks in which the oil and water can be allowed to separate out. All oil contains a certain percentage of water, and consumers should exercise great care in testing their supplies, as the more water there is in the oil the less should be its price. Against these disadvantages the steam system, as already pointed out, has the merit of simplicity —it is easy to work, cheap in first cost, and easily controlled by unskilled labor. If the steam is superheated, and the oil heated as well, very high efficiencies can be obtained.

Compressed-air systems work in a similar manner to the steam system. The fire can be started by compressed air from reservoirs, or by means of a hand-pump on a suitable air receiver in the case of very small boilers. Owing to there being no steam mixed with the atomized oil, the spray will ignite even when the oil contains a considerable percentage of water. It is essential, however, to have the air well heated, as the expanding air tends to produce a very cold spray and so retard combustion.

To overcome this difficulty the air pipes are usually led through the smokebox before coming to the burners. As in the case of the steam burner, much better results are secured by heating the oil also. This is done by means of steam coil in a small tank, through which the oil passes on its way to the burner. When steam has been raised in the boiler, a small steam-driven air compressor will provide the necessary compressed air, the steam from which can be condensed and returned to the boiler. The air pressure required varies with different types of burners—some burners will work with air of a few pounds pressure, and some require as much as 50 lb. per square inch.

In the pressure system the oil is forced by means of a pump through a small hole in the burner, from which it exudes in the shape of a very fine spray. The pressure is equalized by means of a fairly large air vessel, and the apparatus can easily be started by working the pump by hand or by using a small auxiliary hand-pump. After leaving the pump the oil is passed through a steam heater, where it is heated to a high temperature before reaching the burner. In starting, a small auxiliary heater worked with naphtha is often fitted until a supply of steam for the main heater is available. One disadvantage of many mechanical burners is that they are limited to the use of light oils.

However much experts may differ as to the best method of obtaining the required atomization of the oil, there is a general agreement that the combustion of oil fuel requires a larger volume in the furnace than is required for solid fuel.

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DATA REGARDING the softening temperatures of coal ash from several hundred coals from the different fields of the country are contained in Bulletin 20, "Fusibility of ash from coals of the United States," by W. A. Selvig, assistant analytical chemist, and A. C. Fieldner, supervising chemist, just issued by the Bureau of Mines.

Information concerning the fusibility of coal ash has become of considerable value to the consumer of coal, mainly in connection with the troublesome formation of clinker resulting from the melting of the ash constituents of the burning coal. The growing interest in such data has led the Bureau of Mines to make a general survey of the "fusing" or "softening" temperatures of the ash from coals of the United States. It is hoped that this information, when used together with the large number of coal analyses published by the bureau, will assist the consumer of coal in comparing different coals, and in selecting the coal best adapted for this purpose.

Coal ash is the incombustible residue remaining after the complete combustion of coal; it is derived from the inorganic mineral constituents of the coal. The ash-forming constituents are (1) inherent or intrinsic impurities that are present in an intimate mixture with the coal substance, and are derived either from the original material or from external sources such as sedimentation and precipitation while the coal-forming plant remains accumulated; (2) impurities, formed either during the laying down of the coal bed or subsequently, that occur in the form of partings, veins and nodules of clay, shale, "slate," pyrite and calcite; and (3) impurities that become intimately mixed with the coal in the process of mining, such as fragments of roof and floor.

Coal ash is composed largely of compounds of silica, alumina, lime and iron, with smaller quantities of magnesia, titanium and alkali compounds.

# The Electrical Industries and the Coal Situation*

PUBLIC UTILITIES A GREAT FACTOR IN THE FUTURE WELFARE OF THE NATION IN THE CONSERVATION OF RESOURCES. BY JOHN W. LIEB†

IN ORDER TO understand fully the manner in which the electrical industries have been affected by conditions in the coal industry, it is necessary to review the position and importance of the utilities in the life of the nation as representative of the electrical industries; also, to show their intimate dependence upon an adequate, suitable and reliable coal supply.

It is essential that the importance of the utlities in their respective communities be appreciated in order that the facts and conclusions we draw therefrom may be fully intelligible. The development of the utilities to their present expansion and importance, where they now serve practically the entire population of the United States, has occurred largely during the last 40 to 50 yr.

At present, nearly one-third of our industries are supplied by central electric power plants. The total number of consumers for lighting and power exceed 10,000,000 for 1922. Gas was supplied in 1921 to over 9,000,000 consumers. Street railways in 1922 carried over 15 billions of passengers.

SIGNIFICANT UTILITY STATISTICS

A. CAPITAL INVESTED

| | | |
|---|---|---|
| Electric Light and Power.... | 1922 | $5,100,000,000 |
| Electric Street Railways..... | 1917 | 5,699,000,000 |
| Gas Industry ..... | 1922 | 4,000,000,000 |

B. TOTAL KILOWATT CAPACITY OF DYNAMOS

| | | |
|---|---|---|
| Central Electric and Electric Railway Stations ..... | 1921 | 14,466,915 kw. |

C. OUTPUTS, KILOWATT HOURS GENERATED AND CUBIC FEET OF GAS SOLD

| | | |
|---|---|---|
| Central and Electric Railway Stations ..... | 1922 | 46,000,000,000 kw.-hr. |
| Gas Companies—Sold.. | 1921 | 326,950,000,000 cu. ft. |

D. NUMBER OF EMPLOYES

| | | |
|---|---|---|
| Electric Light and Power..... | 1922 | 150,000 |
| Electric Railways ..... | 1917 | 294,826 |
| Gas Companies ..... | 1921 | 73,000 |

According to a recent announcement of the Department of Commerce, the value of manufactured products of establishments engaged in the manufacture of electrical machinery, apparatus, and supplies amounted in 1921 to $833,936,000 and in addition, electrical products to the value of $49,000,000 were reported by establishments classified in other industries. The electrical manufacturing industries gave employment to over 187,000 wage earners in 1922.

Another angle from which to view the importance of the utilities is in their relation to public welfare. Electric and gas lights are essential to the policing of our great cities. Fire protection, water supply, telegraph and telephone service and vertical transportation are all largely dependent for their operation on central station service. Domestic lighting, heating, cooking, and many other household services in our cities are dependent upon the utilities, as in like manner are urban and interurban transportation, shops, factories of all kinds, manufacture of artificial ice, etc.

In the use of electrical energy, the United States outstripped the world—using about half of all the power produced and she far exceeds her principal competitors as seen by the following figures.

KILOWATTS CONSUMED PER CAPITA

| | |
|---|---|
| United States ..... | 472 |
| United Kingdom and Ireland..... | 163 |
| France ..... | 147 |
| Germany ..... | 141 |
| Italy ..... | 85 |

Two small countries, Switzerland and Norway, and also Canada which have large, available water powers exceed the United States in the per capita consumption of electrical energy and have in that regard a material economic advantage.

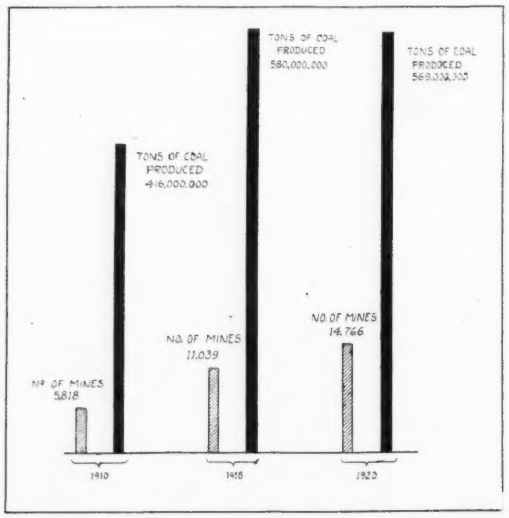



FIG. 1. CHART SHOWING GROWTH IN NUMBER OF MINES AS RELATED TO INCREASE IN PRODUCTION OF COAL

UTILITIES MUST HAVE CONSTANT FUEL SUPPLY

SO ESSENTIAL have the utilities become to our industrial and civic life that should the gas and electric plants of a great city fail to function, an inconceivable catastrophe would result. The public requires that the utilities maintain the continuity of service as a necessity to its health, safety and comfort and demands that the utilities keep in constant readiness the equipment and facilities to carry whatever load may be forced upon them, no matter how high or unexpected the demand or how adverse the circumstances. In order to do this, it is evident that there must be available at all times adequate quantities of suitable fuel. During the past few years, adequate supplies of coal of this character have not at all times been available. The public utlity, gas or electric, must function, and coal is the raw material upon which its service usually depends. For the public

*Address delivered before the New York Electrical League, New York, N. Y.
†Vice President, New York Edison Co.

good, it should, therefore, be placed beyond any danger of failure to obtain adequate quantities of proper fuel.

### The Coal Industry

During the past few years, the gas and electric utilities have had great difficulty in securing coal of the proper quality and in the amounts needed. The supply was unreliable, the principal causes being strikes, car shortages and failures of transportation, due to congestion of equipment, resulting embargoes, etc. The difficulties of maintaining constant service and the high coal costs thrown on the utilities were so great that a review of the situation of the coal industry seems desirable at this point.

Unless otherwise specified, bituminous coal is referred to—the problems affecting anthracite coal though at present critically acute, concern directly the service of only a small number of utilities. We do not, of course, minimize in the least the importance of the supply of anthracite particularly for domestic uses, most vitally affecting as it does the health as well as the convenience of the people.

Since 1910, a vast change has occurred in the mining industry by an excessively rapid development of mine operation. During that time, between 1910 and 1920, the number of mines has increased 154 per cent, corresponding to an increased capacity of over 800,000,000 T. The actual demand for coal, however, reaches from five to six hundred million tons. This great excess development of new mines as compared with the output has seriously interfered with healthy conditions in the coal business. The resultant irregularity of production has been great; thus, in Illinois, in 1921, the average number of days of mine work was only 131, and for the country as a whole in that year it was 149 days. The amount of labor available at the mines is excessive. About 74,000 men were employed in 1921, when 42,053 men could have performed the service by working a more reasonable number of days in the year.

In addition to this, the average annual output per mine decreased from 71,500 T. in 1910 to 38,512 T. in 1920. This would, of course, involve a serious increase in overhead cost per ton for much of the coal produced. To these undesirable conditions must be added the even more serious injuries which have resulted from both mine and railroad strikes during the past few years. In 1922, coal was plentiful in quantity and reasonable in price, considering freight rates, until the great strike occurred on April 1, to be followed by the widespread strike of railway men somewhat later. Though the situation in 1922 was more serious and dangerous than that of 1919-20, it was better handled and the utilities suffered less, although the conditions last year and during the previous coal stringencies were still such as to call for the most earnest consideration.

The opening up of an excessive number of mines, previously referred to, has had its reflection on the railroad situation, making it necessary for them to divide their available cars among over 2900 additional mines in 1918 and 6800 more mines in 1920 than would have been necessary had the average production per mine in these years been maintained on the 1910 basis.

These disturbances in the coal industry have caused prices to fluctuate enormously. We have not yet recovered from the results of the last disturbance and are still paying abnormally high prices, as has been the case since early in the summer of 1922. The annual coal bills paid by the public of the United States are significant.

| | Consumption | Estimated Price |
|---|---|---|
| 1913 ..... | 478,000,000 T. | $565,000,000 |
| 1920 ..... | 567,000,000 T. | 1,200,000,000 |
| Excess paid in 1920 over 1913 | | 528,000,000 |
| | | Increase 128% |

### Difficulties with Coal Contracts

It has been the experience of the utilities that coal contracts are as a rule of little value in providing coal during times of extreme emergency unless protected by priority orders issued and policed under government authority. One of the serious difficulties has been due to the fact that when there is a shortage of coal or coal

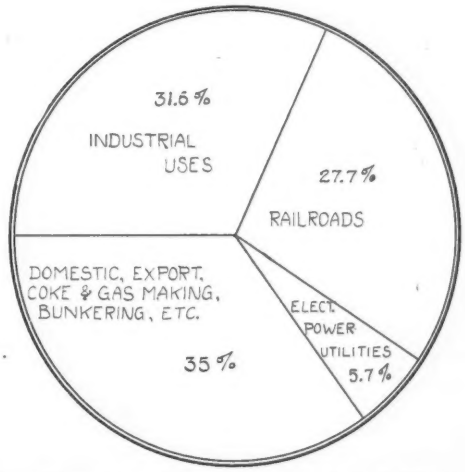



FIG. 2. SHOWING BITUMINOUS COAL DISTRIBUTION AMONG VARIOUS INDUSTRIES AND CLASSES OF CONSUMERS

cars, the supply the utilities receive on their annual contracts is usually pro-rated proportionately with other consumers some of whom may be only "spot" purchasers.

Another question which must be considered, is that of coal quality. This is a particularly serious one to the utilities. In large electric power plants, the kind of fuel which is usable is dependent in large measure upon the design of boilers, stokers, ash handling equipment, etc. Utility plants are designed and located with a view to obtaining the right quality as well as an adequate quantity of fuel, and when the coal is not of the character for which the plant was specifically designed serious difficulties result in the form of deteriorated equipment, reduced output, or possibly even complete shutdown. In the case of the gas industry, the manufacture of gas is a chemical process. It does not consist in utilizing merely the heat in the coal, but must produce products of definite chemical content.

### Some Proposed Remedies

Various remedies have been suggested for stabilizing the coal business, though as yet the Coal Commission has not been convinced that a proper solution has been proposed. One important group of those interested, advocate in essence, that the situation be allowed to work itself out without external government or other interference. A second suggestion is that the government

itself purchase and operate the mines. This plan, though vigorously and continuously promoted by a group of the more radically inclined has been quite universally condemned by the public. Finally, plans have been proposed whereby through the extension of the storage of coal by all users, the seasonal variation of prices of coal and possibly seasonal variations of freight rates, by conservation or economy in the use of coal, and by simplifying its distribution, conditions in the coal industry can be materially improved.

Of the methods for ameliorating fluctuating conditions in the coal industry, the provision of storage facilities seems to offer exceptional advantages. The utilities for self-protection early inaugurated the policy of maintaining generous reserves by storage of coal at their plants. Indeed, they have been a leader in this regard, and through wise buying and handling of these storages have proved to be a helpful stabilizer to the coal industry.

Storage at the mines has also been suggested and this would to a certain extent prevent the irregular daily production outputs from mines caused by fluctuations in the daily car supply.

It has frequently been suggested that much expense and transportation difficulty could be saved by the location of the generating stations at the mine mouth with the transmission of power so generated to the point of use. This has been found successful wherever an adequate supply of water is available for condensing purposes, but it is unfortunate that in America very few rivers of adequate size to provide the necessary flow are available in the coal regions.

### Pumping Coal Through Pipelines

Another scheme that has been proposed and its feasibility has been shown, at least theoretically, is that of pumping coal through a pipe line. The cost and design of the apparatus is well known and no extraordinary engineering difficulties are encountered in its operation. A proportion of 50 per cent by volume between conveyed material and water can be maintained. At 10 ft. per sec., which is not excessive, a 14-in. pipe will carry over 7,000,000 T. of coal per year and this delivery is independent of the length of the pipe.

At the present time, it is estimated that the cost of delivering a ton of coal, including fixed charges, from Scranton to the New Jersey side of the Hudson would probably not exceed 50 cents per ton, to which would have to be added the ordinary charges for lighterage and handling in the port of New York. It has been estimated that approximately 18,000,000 to 20,000,000 T. of coal pass through New York City every year, which would absorb the capacity of three 14-in. pipes.

### Coal Conservation—Super Power Systems

America is noteworthy for her extravagance in the use of coal. Efforts towards conserving this vitally important natural resource are wise for the protection of the future of the country, and are also in a direction which tends to relieve the strain of heavy coal transportation. In the Government Super Power Survey, it is estimated that the power of this country can be supplied with use of about two pounds of coal per kw.-hr., as against an average of nearly three times that amount as at present used. The savings to be obtained are largely through the possibility of the operation use of large, highly economical, suitably located power stations taking advantage of the diversity factor in the varied industries of the several districts covered, lessening the reservation of spare equipment, making possible the electrification of railroads. The building of great power systems which are inter-connected, as contemplated by the super-power zone, also makes possible utilization of many water powers which otherwise would not be available for development.

### Essentials to Utility Growth

It is evident that the public utilities hold forth wonderful opportunities for advancing the welfare of the nation through the conservation of coal and oil, simplifying the distribution of fuel, contributing to its conservation by the utilization of water power, and providing a supply of abundant, reliable and cheap power to our industries.

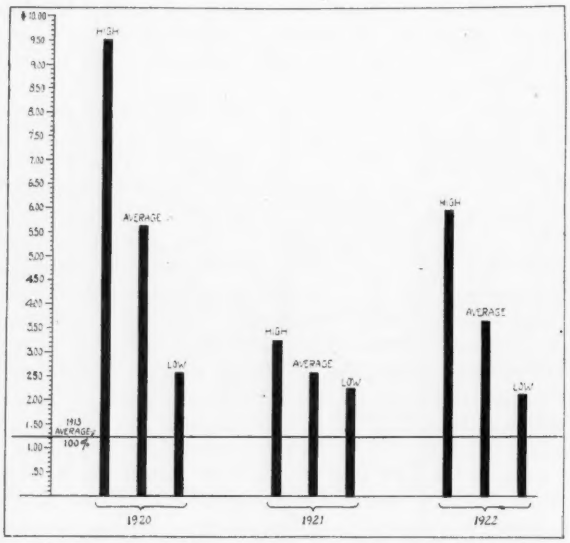



FIG. 3. FLUCTUATIONS OF AVERAGE MONTHLY BITUMINOUS MINE COAL PRICES

In order that their full value may become available to the nation, great systems covering large areas, and supplying great loads will be necessary. To accomplish this purpose, the utilities must continually expand, ever developing larger and more extended systems. This development is one of state-wide importance and such public regulation as is needed should be of a state-wide character. Systems of this kind already include scores and hundreds of municipalities within their transmission areas, but they necessarily must be operated as a unit; it is impossible for them to develop or give good service to the public if they are subject to the harrassing interferences of all of the municipal or minor political establishments through which they may extend and in which they operate. Nor will such a consummation as the public desires and the companies wish to provide be possible unless state-wide regulation of a broad and equitable character is maintained and the laws and rulings governing the utilities are of a helpful and stable character and such as to attract the large quotas of capital which it is necessary to obtain each year to provide for the rapid extension of the public utilities in order that they may serve the public adequately, efficiently and economically.

# Diesel Engines in a Portland Cement Plant

Operating Results Secured by Western States Portland Cement Co. Have Been Favorable to Diesel Type of Prime Mover. By C. M. Carman*

DIESEL engines have come to stay in the Portland cement industry. This statement could not have been made 10 or 12 yr. ago, as there were no Diesel type oil engines operating in any cement plant in the United States. At that time, there existed some doubt as to the suitability of installing such a prime mover for cement mill operating conditions, for the Diesel had not proven itself in this country to be as reliable as the steam engine or as capable of continuous operation. The process of manufacturing Portland cement being necessarily a continuous one, the points of reliability and durability were of the utmost importance. This product requires a great deal of power per barrel of cement finished, which must be supplied day and night, month after month.

It is only in the last 5 or 6 yr. that the Diesel has had recognition in the cement industry, but it has gained steadily. The rapid development of the oil fields of this country has been a very definite factor in this growth, as fuel oil can now be obtained in almost all parts of the country instead of only in certain favored localities. One of the first of the Portland cement plants to be Diesel engine equipped is that of The Western States Portland Cement Co. at Independence, Kansas. This company operates one of the largest plants west of the Mississippi River, having a daily capacity of 4000 bbl. of finished cement.

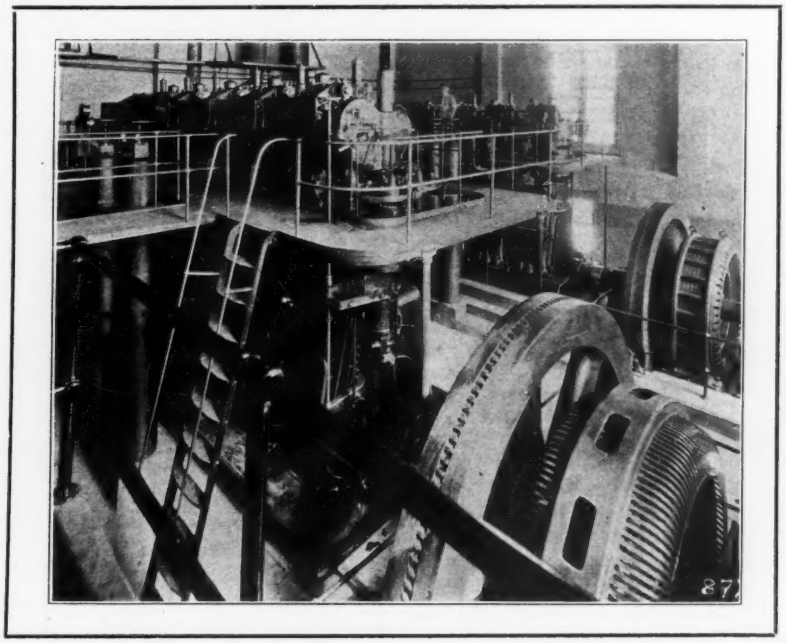


FIG. 1. TWO DIESEL UNITS, ONE OF 1000 HP. AND THE OTHER 500 HP., PRODUCE THEIR SHARE OF POWER FOR CEMENT MILL OPERATIONS

Originally the power plant consisted entirely of steam driven prime movers, running non-condensing. There were three units, all of the same size—all 1100 i.hp., 107 r.p.m., horizontal, side-crank, cross-compound McIntosh & Seymour Corporation steam engines. Each had an 800-kw. (1000 kv.a. at .8 P.F.) General Electric alternator mounted on the crank shaft, that generated three-phase, 25-cycle, 600-v. current. These units served the mill until 1916, when a fire did so much damage to one of these engines that it had to be scrapped.

Following the fire, the officials of the company made a thorough investigation of the prime movers on the market at that time and decided on a Diesel installation. To provide for a more flexible power generating station, one that would operate more smoothly than the old layout and be capable of handling the fluctuating load conditions of the plant, it was decided to buy two units of different sizes. Accordingly a 1000-hp. and a 500-hp. engine were installed. These were obtained from the McIntosh & Seymour Corporation. One of them was a 1000-b.hp. vertical, six-cylinder 160-r.p.m., type B44 engine direct connected to an 800-kw. (1000 kv.a. at .8 P.F.) General Electric alternator. This generator is mounted upon an extension shaft driven from the engine crank shaft through a rigid coupling. Three-phase, 25-cycle, 600-v. current is produced.

The second but smaller unit consisted of a 500 b.hp., vertical, four-cylinder, 167 r.p.m. engine and 360 kw. alternator. The d. c. excitation current for both generators is furnished by separate motor driven exciters which will be described later in this article.

All of this equipment is contained in one building, which at the present time is being enlarged to provide room for a new switchboard and a new steam turbine. This new turbine installation will consist mainly of a 4000 kw. (4445 kv.a. at .9 P.F.) General Electric-Curtis type turbo-generator set with a 10,000-g.p.m. Alberger surface condenser and pumps. The steam for this new unit will be generated by two 1087 b.hp. Edge Moor Iron Co. waste heat boilers that were recently installed and are now in successful operation. These boilers utilize the heat energy contained in the waste gases produced in the manufacturing process. It is of interest to note that the new generator is designed for operation with a power factor of 90 per cent instead of the 80 per cent of the older units. This improvement has been made possible by the installation and operation of two 500-hp. synchronous motors in one of the departments of the mill.

The power house itself is built of salmon colored face brick on the outside and common brick, painted, on the inside. The building is divided longitudinally in the

*Mechanical Engineer, Western States Portland Cement Co.

center by a brick partition, making two equal sized rooms. The north half of the building is called the boiler room. In this room there are four batteries of two 310-b.hp. Stirling boilers each and several auxiliaries. These boilers are arranged for either natural gas or oil firing, but are not used extensively as long as the waste heat boilers are in operation. The auxiliaries are all in the west end of the structure. In one corner there are two Cochrane open type feed water heaters and a double acting duplex plunger pump for feed water. Nearby there is an Ingersoll-Rand cross compound motor driven air compressor for furnishing compressed air at 60 lb. pressure for general use in the mill. And in another corner are grouped the pumps for handling the fuel oil for use in the Diesel engines and that used under the Stirling boilers.

In the south half of the power house is the engine room. Here the four generating units are arranged in a single row, flanked on the west end by the switchboard and the smaller auxiliaries. From west to east the equipment is arranged as follows: the switchboard, the two steam engines, and the two Diesel engines; the new turbine, when erected, will complete the layout. The auxiliaries are three motor driven and one steam driven generators furnishing direct current for electric cranes in the cement plant and for generator excitation service. The steam driven set consists of a Fleming-Harrisburg engine driving a 125-v., 393-amp. exciter at 300 r.p.m. One 100-hp. motor with extended shaft drives two 140-v., 286-amp. exciters at 500 r.p.m. One 50 hp. motor drives one 125-v., 230-amp. exciter. And for direct current for electric cranes there is a 100-hp. Westinghouse motor driving a 120-v., 834 amp. Bullock generator at 650 r.p.m. The pump room is directly below the switchboard and contains the plant circulating and fire pumps.

One feature of the engine room is that the main floor of the building where the two Diesels are placed is 10 ft. lower than the operating floor around the steam engines, which makes the Diesels appear to be in a sort of pit. This arrangement is good, however, for it puts the runway around the top of the oil engines at approximately the same level as the steam engine operating floor. These runways are connected with each other and to the steam engine operating floor by steel bridges. This is an advantage for it permits of free and unrestricted passage from unit to unit without the necessity of having to climb up and down ladders to reach some certain point. Another important advantage in this arrangement is that the operator is clearly visible at all times to the switchboard operator. The two Diesel engines have a liberal amount of floor space around them, which allows certain repairs to be made on the spot. To aid in repair work of all kinds there is a 10 T.

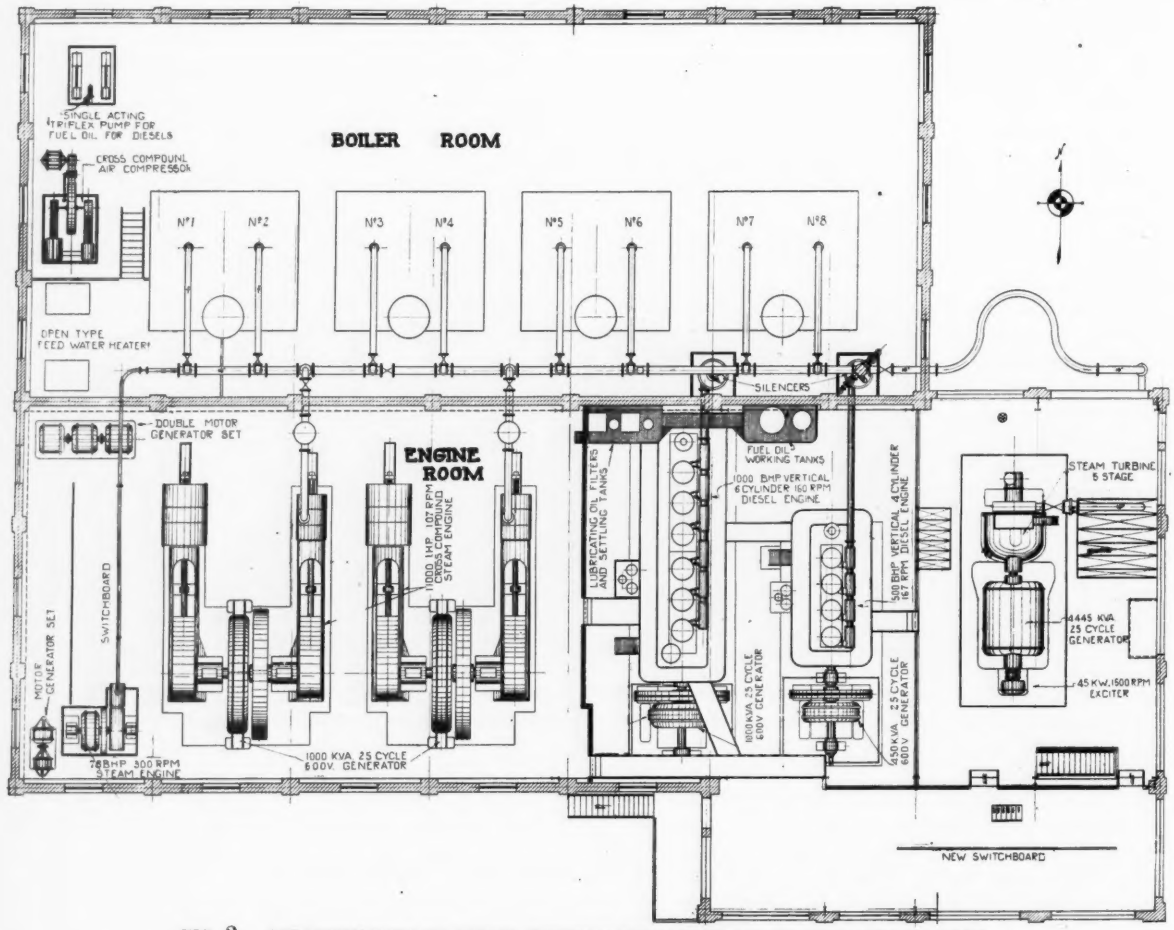



FIG. 2. ARRANGEMENTS OF DIESEL ENGINES WITH RESPECT TO THE STEAM UNITS

capacity Whiting Foundry Equipment Co. hand-operated traveling crane serving the two oil engines. Pulling pistons by hand power was found to consume so much time in hoisting that a 5-hp. motor was geared to the hoisting drum, thereby speeding up this operation.

Up high on the north wall of the engine room, just under the crane girder, is a steel platform supporting the lubricating oil filters and the fuel oil working tanks. The starting bottles are arranged alongside of the engines so that they may be operated from the runway on the upper part of the engines. The exhaust gas from each engine is run to an individual silencer placed in the boiler room. No attempt is made to conserve the heat energy in these gases, although a series of tests made last year with a boiler connected to the exhaust pipe proved the practicability of using the gas to furnish heat in the building in the winter months.

Various departments of the mill where heat is required are equipped to burn fuel oil. The fuel oil used in the mill may or may not be of the same gravity as that used in the Diesel engines. At the present time an oil of a heavier gravity is being used in the mill than is possible to use in the Diesel engines. This condition necessitated installing a fuel oil unloading station capable of handling oils of different gravities. The station is just north of the power house, separated from it by a spur of the plant railway system. Two pipe lines parallel the track here: one of these is a steam line with connections for attaching to the steam coils in the tank cars for heating the oil before and during unloading. The other line is the oil unloading line. It has suitable connections for emptying two tank cars at once. From the tank cars the oil flows by gravity into either one of two 25,600-gal. working tanks. If it is Diesel engine fuel oil it flows right out of these tanks into the suction line of a Fairbanks-Morse plunger pump, which boosts it into a 265,000-gal. storage tank on the top of a hill about two hundred yards away. From this tank it flows by gravity to the Diesel fuel oil pump mentioned previously as being located in the boiler room. This pump is a Deming 3-in. by 3-in. single-acting triplex driven by a 3 hp. alternating current motor, and places the oil in the service tanks in the engine room. Steam heated Schutte & Koerting oil heaters in the line between the pump and tank raise the oil to any desired temperature.

In case the heavier fuel oil is to be unloaded, a slightly different procedure is necessary. Usually the cars are received from a nearby refinery while still warm, which is a great help in handling the heavier grades of oil. Using fuel oil of gravity of 1.0 plus in cold weather means that there must be heating connections if the purchaser hopes to escape demurrage payments on tank cars. The same unloading connections are used for both grades of fuel oil, although but one grade is actually unloaded at a time. The heavier oil is stored in the 25,600-gal. working tanks which are both equipped with steam coils to keep the oil fluid. No great storage of the heavier oil is necessary with the fuel supply coming regularly from a neighboring town, as is the case at present. From these working tanks the heavy oil is pumped to different parts of the plant by a Goulds single acting triplex pump. The pumps for handling both oils from the tanks are placed side by side in a pit at one end of the unloadng station and are so connected that either pump may be cut in in place of the other pump in case either one of them is temporarily down for any reason. Each pump has a pressure relief valve on the discharge side that leads back to the suction line to prevent any building up of pressure from any cause. Two Elliott duplex basket type strainers are installed—one on each suction line.

Water for cooling the cylinders and the exhaust manifold of the Diesel engines and for all plant purposes, except drinking, is obtained from the Verdigris River, about 200 yd. from the power house. There are two pumps in a pump station near the river bank which bring the water to the plant. These are both 8-in. 1600 g.p.m. Worthington vertical volute single suction pumps operating under about 90-ft. head. Each is driven by a 50-hp. General Electric vertical motor direct connected by means of a flexible coupling. The pumps place the water in a 50-ft. diameter by 13 ft. deep reinforced concrete reservoir about 50 ft. from the west end of the power house. The plant circulating pumps, which also handle the water for the Diesel engines, receive the water by gravity from this reservoir and distribute it throughout the plant at 60 lb. pressure. A small motor driven plunger pump saves some of the water that has passed through the cooling system of the oil engines and places it in the feed water heaters for the Stirling boilers when they are operating. When the new turbine installation is completed, the water from the Diesel Engine system will be pumped into the spray pond that is being constructed in connection with the new condenser.

The power plant is too close to the main part of the cement plant to be as free of dust as it should be. The dust, which frequently blows directly over the power house, does a great deal of damage to the engines as the intake air is not washed. This condition will be remedied in the near future by the installation of an air washer for the new turbine that will have a connection to each of the Diesel engines. The gritty intake air has been hard on cylinder rings and liners and has been the cause of an excessive amount of oil being used.

In Table II are shown the kilowatt-hours generated by each unit, the number of hours actually operated, the average load carried, the per cent of rated load carried, the total fuel oil consumption, the number of pounds of fuel oil used per kilowatt-hour produced, and the number of pounds of fuel oil used per horsepower-hour. At this point it is of interest to insert the fuel consumption guaranteed by the McIntosh & Seymour Corporation based on using a fuel oil containing not less than 18,500 B.t.u. per lb. These are as follows: Full load, .408 lb. per b.hp. per hr.; three-fourths load, .420 lb.; one-half load, .463 lb.; one-quarter load, .629 lb.

These rates are for engines on the testing block when new, every condition being ideal, so that the results obtained from the two engines in the three-year period shown compare very favorably. The average gravity of the fuel oil used has been 27 deg. Baumé; testing 19,330 B.t.u. per lb. as an average. This oil averages 7.4 lb. per gal. in weight. There have been many times since the engines began to operate in this plant that they have equaled the guaranteed results; instances being when new liners have been placed in the cylinders and new piston rings put on the pistons. Table II shows again that the smaller engine has not been as economical to operate as has the big one, but as stated before, it is handicapped by conditions having no bearing on its

mechanical efficiency as a machine, which is every bit as good as the big Diesel.

To show the cost of power generated by these units, Table III has been compiled, covering a 3-yr. period. No attempt has been made in this table to separate the cost per kilowatt-hour generated by each engine.

No depreciation has been charged in the costs in Table III, it will be noted. Owing to excessive wear due to unwashed air being used, the amount of lubricants used in the cylinders has been excessive. About 8 to 9 gal. has been about the average daily amount added as make-up for the big engine and about 4 gal. for the 500-hp. engine. New liners put in this winter have practically halved this daily consumption. Oil in the crank case is usually replaced about once in 3 mo. The engines are both equipped with Richardson-Phoenix force feed oil pump system which works very satisfactorily.

These two Diesel engines were installed in the early months of 1917 and placed in operation during the last half of the same year. Since then they have been in service continuously with only short periods of idleness.

In Table I are arranged the records of each engine in such a way that anyone can easily see just how dependable the two engines have been. It will be noted that the time lost for repairs during the years covered is remarkably little, and is just one-third of the time lost for other causes. On paper the small engine has not shown such a high operating efficiency as the large engine, but by examining the tabulated figures it is plain that it was not mechanical trouble that caused this difference. The 500-hp. engine has been used to carry the peaks in the load, and does not fit in with the rest of the power plant as readily as the larger units. Consequently it has been started and stopped more than any of the other engines and has lost in efficiency thereby. It shows less time being lost for repairs than does the 1000-hp. Diesel although there is not a great deal of difference. This difference is about in line with the difference in actual operating time between the two. Many more operating hours have been obtained by taking advantage of every time the engine is down for any cause other than for repairs to examine it and make any minor adjustments necessary.

TABLE I. OPERATING RECORD OF 1000 HP. DIESEL ENGINE

| Year | Total Number of Hours Actually Operated | Total Possible Number of Operating Hours in the Same Period | Total Number of Hours Mill was Shut Down | Total Number of Hours Engine was Down for Repairs | Total Number of Hours Engine was Down for Other Causes | Total Possible Number of Operating Hours in Operating Period of the Year | Per Cent of Time Operated in Operating Period of the Year | Per Cent of Time Down for Repairs |
|---|---|---|---|---|---|---|---|---|
| 1917..... | 1659 | 2208 | 0 | 35.5 | 513.5 | 2208 | 75.0 | 16.1 |
| 1918..... | 7151.5 | 8760 | 0 | 405.0 | 1203.5 | 8760 | 81.7 | 4.6 |
| 1919..... | 5902.5 | 8760 | 1992 | 329.5 | 2528.0 | 6768 | 87.2 | 4.9 |
| 1920..... | 7910.0 | 8784 | 0 | 492.0 | 382.0 | 8784 | 90.0 | 5.6 |
| 1921..... | 6986.0 | 8760 | 717 | 97.5 | 1676.5 | 8043 | 87.0 | 1.2 |
| 1922..... | 6576.0 | 8760 | 1800 | 112.5 | 2071.5 | 6960 | 94.5 | 1.6 |
| Total.... | 36185.0 | 46032 | 4509 | 1472.0 | 8375.0 | 41523 | | |
| Average..... | | | | | | | 87.0 | 3.5 |

RECORD OF 500 HP. DIESEL ENGINE

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1917..... | 1707.5 | 2208 | 0 | 0.0 | 500.5 | 2208 | 77.2 | 0.0 |
| 1918..... | 5542.0 | 8760 | 0 | 123.0 | 3095.0 | 8760 | 63.2 | 1.4 |
| 1919..... | 5393.5 | 8760 | 1992 | 184.0 | 3182.5 | 6768 | 81.2 | 2.7 |
| 1920..... | 6522.5 | 8784 | 0 | 618.0 | 1644.0 | 8784 | 73.3 | 7.0 |
| 1921..... | 5224.5 | 8760 | 717 | 204.5 | 3331.0 | 8043 | 65.0 | 2.5 |
| 1922..... | 6306.0 | 8760 | 1800 | 245.0 | 2209.0 | 6960 | 90.7 | 3.5 |
| Total.... | 30696.0 | 46032 | 4509 | 1374.5 | 13962.0 | 41523 | | |
| Average..... | | | | | | | 73.8 | 3.3 |

TABLE II. PRODUCTION AND FUEL CONSUMPTION RECORD OF 1000 HP. DIESEL ENGINE

| Year | KW. Hours Generated | Number of Hours Operated | Average Number KW. Generated per Hour | Per Cent of Rated Load Carried | Number of Barrels of Fuel Oil Consumed | Pounds of Fuel Oil Consumed per KW. Hour | Pounds of Fuel Oil Consumed per IHP. Hour |
|---|---|---|---|---|---|---|---|
| 1920..... | 5771395 | 7910.0 | 730.0 | 91.2 | 12696.2 | .68371 | .5154 |
| 1921..... | 5129400 | 6986.0 | 735.0 | 92.0 | 11021.0 | .66778 | .4687 |
| 1922..... | 4443600 | 6576.0 | 676.5 | 84.5 | 10089.2 | .70873 | .4783 |
| Totals.... | 15344395 | 21472.0 | 2141.5 | | 33806.4 | | |
| Averages. | 5114798 | 7157.3 | 713.83 | 89.2 | 11268.8 | .68674 | .4695 |

RECORD OF 500 HP. DIESEL ENGINE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1920..... | 1542411.0 | 6522.5 | 236.5 | 67.5 | 3477.3 | .70069 | .4730 |
| 1921..... | 1208380.0 | 5224.5 | 231.0 | 66.0 | 2670.0 | .68674 | .4635 |
| 1922..... | 1421390.0 | 7306.0 | 225.5 | 62.5 | 3284.9 | .71827 | .5387 |
| Totals... | 4172181.0 | 18053.0 | 693.0 | | 9432.2 | | |
| Averages. | 1390727.0 | 6017.66 | 231.0 | 64.2 | 3144.06 | .70190 | .4738 |

NOTE—Both generators considered as being 90 per cent efficient for obtaining results in last column.

TABLE III. COMPARISON OF OPERATION COST FOR THREE YEARS

| CLASS | 1920 Total Cost | 1920 Cost per KW. | 1921 Total Cost | 1921 Cost per KW. | 1922 Total Cost | 1922 Cost per KW. | 1921-22-23 Total Cost | 1921-22-23 Cost per KW. |
|---|---|---|---|---|---|---|---|---|
| Operating Labor..... | $11,476.72 | .001569 | $10,882.45 | .001717 | $11,289.40 | .001926 | $33,648.57 | .001724 |
| Repair Labor..... | 2,636.08 | .000360 | 3,075.77 | .000485 | 3,028.65 | .000516 | 8,740.50 | .000448 |
| Miscellaneous Operating Supplies... | 60.84 | .000008 | 178.95 | .000028 | 316.57 | .000054 | 556.36 | .000028 |
| Repair Supplies..... | 4,792.08 | .000655 | 7,022.34 | .001108 | 6,453.06 | .001100 | 18,267.48 | .000936 |
| Lubricants and Waste..... | 4,313.09 | .000590 | 6,442.34 | .001017 | 5,537.21 | .000944 | 16,292.63 | .000835 |
| Fuel..... | 43,886.58 | .006001 | 24,693.76 | .003896 | 23,501.44 | .004007 | 92,081.78 | .004718 |
| Total..... | $67,165.38 | .009183 | $52,295.61 | .008251 | $50,126.33 | .008547 | $169,587.32 | .008689 |

# Indicators for Engine Speeds Above 2000 R.P.M.

LOW INERTIA REQUIREMENT HAS RESULTED IN THE DEVELOPMENT OF THREE DIFFERENT TYPES OF HIGH SPEED INDICATORS

ATTENTION is being given at the present time, by British engineers, to the development of indicators for high-speed engines. This interest has been brought about due mainly to the requirements of internal combustion engines, many of which run at speeds of 2000 r.p.m. or more.

Ordinary types of indicators cannot be used with reasonable accuracy at speeds exceeding 350 r.p.m. unless all reciprocating parts are reduced in weight and movement to a minimum, and even then the practical limit in speed is reached at about 600 r.p.m. The effect of inertia upon the accuracy of indicator cards is well understood at the higher speeds of steam engine practice, for under those conditions it generally is advisable to obtain a short card and use a heavy spring rather than obtain a long card and use a light spring.

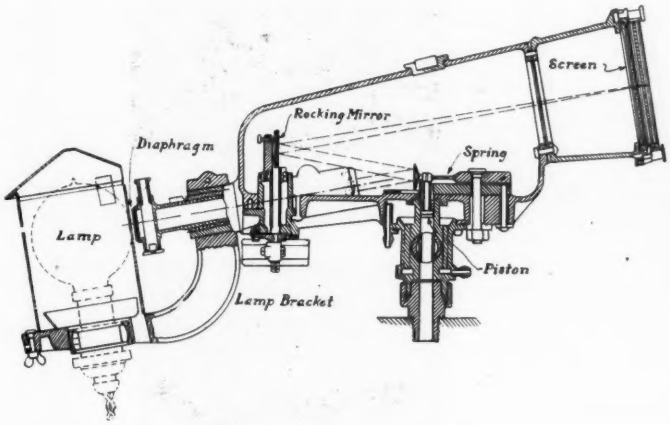



FIG. 1. CROSS SECTION OF OPTICAL INDICATOR

Indicators of the ordinary type have the advantage that a permanent diagram of convenient size for direct measurement can be obtained in a few seconds; further, they are portable, relatively rugged, and as adaptable to service in the field as in the laboratory. These points are all sacrificed to a more or less degree in the present high-speed indicators.

Three general types of high-speed indicators have been developed. These may be classified as: the optical indicator, which utilizes a beam of light; the micro-indicator, which as the name implies, produces a card of small dimensions; and, the electrical indicator, which though applicable to extremely high speeds, does not follow through a complete cycle.

Optical indicators were the first of the high-speed type to receive the attention of investigators. They produce the conventional diagram, showing pressure variations of the complete cycle, by means of a ray of light projected on a ground glass screen. Due to the high speed, the outline traced by the light ray appears as a continuous line on the screen. A record of the diagram may be made by substituting a photographic plate for the ground glass screen.

In Fig. 1 is shown a cross section of a typical optical indicator. The instrument consists essentially of a camera like enclosure to one end of which is attached a lamp bracket. The free end of this bracket supports a lamp of high intensity. Immediately facing this lamp is the diaphragm which allows a single pencil of light to pass through the optical focusing system to a mirror which is secured to the upper end of the piston. The opening through the diaphragm is less than 0.002 in. in diameter. The light is then reflected to the second mirror which is driven through a small angle from the engine piston. The ray of light is then reflected to the screen. It is in this latter stage that the piston and oscillatory motions are amplified.

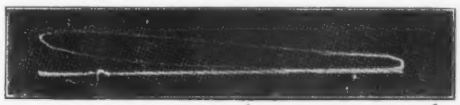


FIG. 2. CARD MADE BY OPTICAL INDICATOR AT ENGINE SPEED OF 1000 R.P.M.

FIG. 3. CARD MADE BY OPTICAL INDICATOR AT ENGINE SPEED OF 1700 R.P.M.

The instrument is secured to its base by means of a suitable bushing, directly above which is located a water cooled cock. This cock is bolted to the cylinder which is also water cooled. Lubrication is obtained by means of a small hand pump which feeds oil under pressure directly to the cylinder. The cylinder area is 0.125 sq. in. and the piston movement is 0.08 in. It is at once evident that the effect of inertia has been reduced to a minimum through the light weight of moving parts, the elimination of such parts as the straight line link motion and also through the short travel of the piston.

Since the effect of vibration on the mirrors introduces a serious error, it is essential that the instrument be secured to a solid base free from engine vibration. Connection to the engine should be made through a tube arranged with bends for flexibility.

Located between the photographic plate and the mirrors is a clear glass screen. This is to prevent oil, which blows into the camera, from coming in contact with the plate.

In Fig. 2 is shown a card taken at an engine speed of 1000 r.p.m. The card shown in Fig. 3 was taken at an engine speed of 1700 r.p.m.

### THE MICRO-INDICATOR

MICRO-INDICATORS are of the cylinder and piston type, the novel feature being the production of small scale diagrams on transparent celluloid. It has been found that lines produced on this material are of such optical

characteristics as to be clearly defined and readable to a high degree of accuracy when enlarged. A further advantage of this instrument lies in an automatic switch which controls the recording stylus so that it remains in contact with the recording surface only for one complete engine cycle.

Sectional and plan drawings of the micro-indicator are shown in Fig. 4. The instrument is attached to the engine cylinder by means of suitable bushings. The range of the instrument can be extended over a wide variation of engine pressures by a change in diameter of cylinder bushings and pistons. The piston rod C, formed solid with the piston, is kept in firm contact with the pressure spring E by means of the small spring D. The spring E is bolted firmly to the rigid frame V.

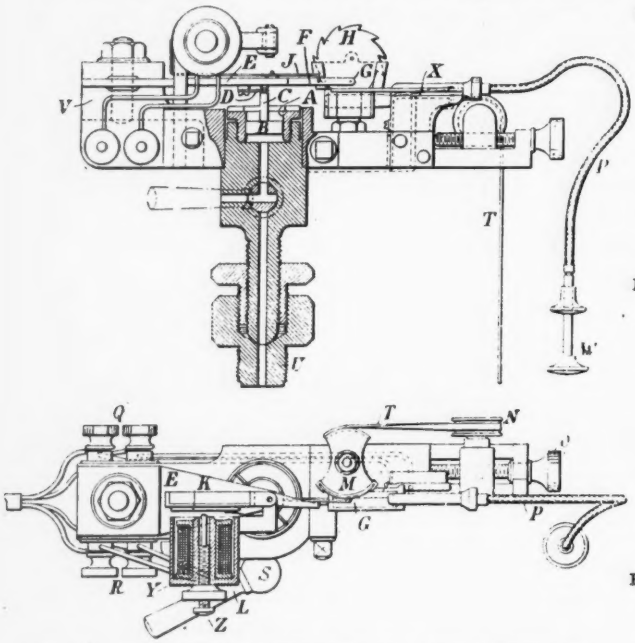



FIG. 4. DIAGRAMMATIC SKETCHES OF A MICRO-INDICATOR

Attached to the pressure spring is a light arm F which carries the recording stylus G. This stylus produces records near the edge of the celluloid disk H, which is carried on and bent to conform with the surface of the segment of a cylinder M. This cylinder is given a reciprocating motion about its axis through the light steel tape T, which passes over the adjustable guide pulley N. The other end of this tape is connected to a crank driven at engine speed. The travel of the periphery of the drum M is about 0.119 in. and the mean piston travel is about 0.031 in. As is evident from these dimensions it is necessary to use a microscope to study the cards, or enlarge them if direct measurements are to be made.

On depressing the wire control push W, the celluloid disk H is rotated one-tenth revolution, thus bringing a fresh recording surface into position, at the same time it closes a circuit X through an electro-magnet in the automatic switch. This magnet actuates a simple form of escapement which closes the circuit through the electro-magnet Y, thus attracting the armature K and bringing the stylus against the face of the celluloid disk, the stylus being held in this position for one cycle only, after which the arm returns to its original position.

Both the cylinder and piston are made of hard steel. An indicator has been applied to a motor car engine and left working continuously for 600 mi., equivalent to more than a million impulses, but no appreciable wear has taken place in either the cylinder or piston.

Records may be made at the rate of one per second. These records have the advantage that they are permanent and are unaffected by water or oil.

It is anticipated that this indicator may be used to make diagrams of aircraft engines during flight, thus obtaining actual atmospheric temperature and pressure conditions impossible of attainment on the test block. It would also prove of value for tests of locomotives, since diagrams may be obtained by pressing a button in the cab thus avoiding the somewhat hazardous process connected with the use of other forms of indicators.

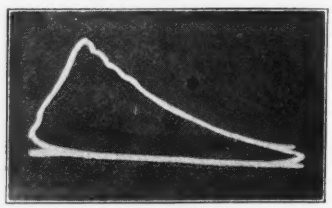


FIG. 5. ENLARGEMENT OF MICRO-INDICATOR CARD TAKEN DURING ROAD TEST AT ENGINE SPEED OF 1200 R.P.M.

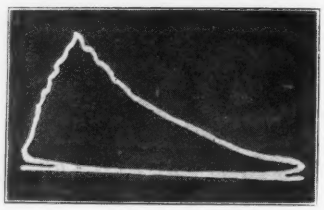


FIG. 6. ENLARGEMENT OF MICRO-INDICATOR CARD TAKEN DURING ROAD TEST AT ENGINE SPEED OF 900 R.P.M.

In Fig. 5 and Fig. 6 are shown photographic enlargements of cards made on road tests.

### Electrical Indicators

In the electrical indicator the varying cylinder pressures are not recorded directly, but the time is noted at which the pressure in the cylinder just balances some known standard pressure. By gradually increasing the standard pressure, a set of time pressure records is obtained which comprises the whole range of engine pressures, although each pair of records belongs to a different engine cycle. It should be noted that there will be but two points of balance in each cycle for any given pressure, one during the compression and explosion stroke when the pressure is rising and one during the expansion stroke when it is falling. Thus by making a record at various pressures in a number of cycles a diagram of the conventional type may be constructed.

In the English instrument known as the Royal Aircraft Establishment Electrical Indicator, the balance point is obtained by the engine pressure just lifting a small valve loaded with a known air pressure. The moment of lift is recorded by the breaking of an electric circuit, of which the valve forms part. The breaking of the circuit causes a spark, which perforates a sheet of paper on a rotating drum running at half engine speed.

The sparking point is attached to a piston in the indicator cylinder which is driven forward by air pressure against the resistance of springs. It is essential that the balancing pressure be the same in both valves mentioned, in order that the instant at which sparking occurs will always coincide with a definite position of the sparking point. Since the rotations of the drum correspond with those of the engine, the sparking will take place at fixed positions on the drum.

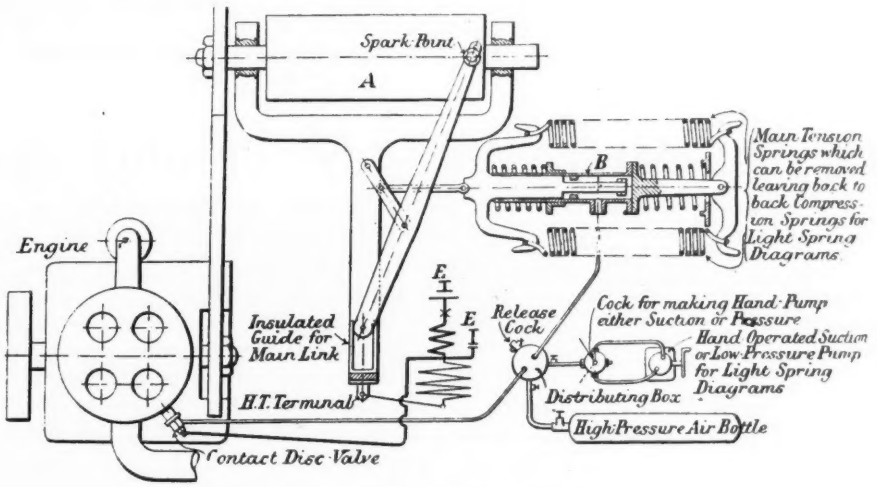

Spark Point
A
B
Main Tension Springs which can be removed leaving back to back Compression Springs for Light Spring Diagrams
Engine
Insulated Guide for Main Link
H.T. Terminal
Contact Disc Valve
E
E
Release Cock
Cock for making Hand Pump either Suction or Pressure
Hand Operated Suction or Low Pressure Pump for Light Spring Diagrams
Distributing Box
High Pressure Air Bottle

FIG. 7. DIAGRAMMATIC SKETCH OF AN ELECTRICAL INDICATOR

To illustrate the action of the instrument, consider what happens for one cycle. Air pressure is admitted to the indicator cylinder and to the balanced valve. This pressure has reached say 50 lb. per sq. in. and the sparking point is opposite that point on the drum. As soon as the compression pressure amounts to 50 lb., the valve is driven off its seat and a spark occurs, which punctures the paper on the drum. The pressure in the engine cylinder continues to rise and then falls. At the instant it descends to 50 lb., the valve is driven to its seat again by the air pressure and another spark occurs. In the interval between the two sparks, however, the drum has made a portion of a revolution and as a result the paper is punctured at a different point.

In Fig. 7 is shown a diagrammatic sketch of this indicator. The rotating drum A is driven from the engine. The indicator cylinder is shown at B.

Besides the indicator there is required, a supply of air at a pressure higher than that to be measured, a high tension coil complete with source of current for producing the spark and suitable valves and gages for controlling the air.

It is at once evident that this instrument is bulky and essentially a laboratory instrument; however, it has the advantages that it may be installed with the registering mechanism at a reasonable distance from the engine.

Satisfactory results have been recorded at 3000 r.p.m. and there appears to be no reason why speeds of 10,000 r.p.m. cannot be dealt with, if desired. The instrument could readily be modified to plot the pressure curve automatically.

There is a great amount of development still to be done before the high-speed indicator will have become as practicable and serviceable as is the ordinary form of indicator; however, the necessity and demand for a good practical instrument has aroused the interest of investigators and it will probably not be long before such an instrument will be available.

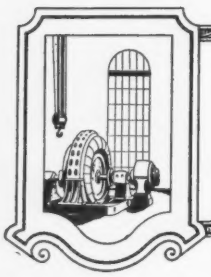
Acknowledgment is due to Engineering of London for the illustrations and data used in the preparation of this article.

# Fuel Recovered from Ash by Magnetic Separation

COKE AND unburnt coal in ash often constitutes a considerable loss of fuel, and up to the present no effective method of recovery has been forthcoming. According to an article which appeared recently in Engineering, Messrs. Fried Krupp, in Germany, have devised a magnetic separator for this purpose.

Practically all coals contain iron in the form of pyrites, which has no magnetic properties. The burning of coal, however, converts the pyrites into oxides which are magnetic, and as all of the iron passes away with the slag, the metal exists there in a much more concentrated form than in the original coal. These facts are taken advantage of to effect the separation. The machine employed consists essentially of a magnetic drum over which the furnace refuse is passed. The drum rotates slowly about a horizontal axis, just as in the case of an ordinary magnetic separator.

Ash to be treated is delivered by a bucket elevator to a vibrating screen which separates it into various sizes. Each size is passed separately on to the circumference of the drum. Slags containing iron are held magnetically to the surface for a portion of the revolution, and then drop off into suitable receptacles as the current exciting the portion of the drum which held them is automatically broken. Coal and coke which may be present do not adhere to the drum, but leave its surface directly after contact with it, and fall into their own receptacles. It is said that lumps of slag up to 3-in. mesh will adhere to the drum and thus be eliminated from the fuel.



# ELECTRICAL MACHINERY FOR LIGHT AND POWER

# Phasing Out Alternators and Parallel Operation

A Practical Discussion of Various Methods of Synchronizing Alternators for Parallel Operation. By F. C. De Weese*

IT IS the desire of the writer to show in this article simple methods of phasing out three-phase alternators and to show successful methods of parallel operation. It is not the purpose, however, to enter into a theoretical treatise on the subject, but only to show in a simple understandable manner enough theory to make the points in question more clearly understood, as it has been the observation that the great majority of men who are called upon to perform this class of work, are not so much interested in the why and wherefore of such matters as they are in being sure of their ground and obtaining correct results.

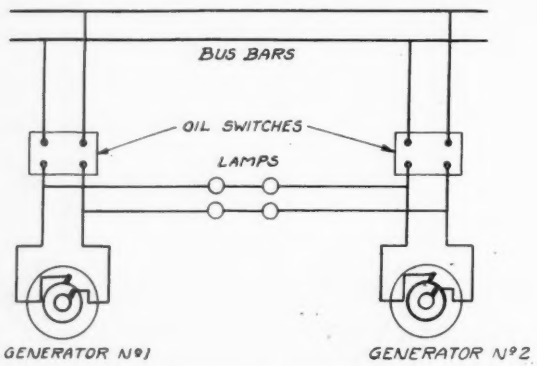



FIG. 1. ELEMENTARY DIAGRAM OF CONNECTIONS FOR SYNCHRONIZING SINGLE PHASE MACHINES

Three methods of phasing out three-phase machines will be described, each of which is comparatively simple and absolutely safe.

One of the early methods of synchronizing alternating current machinery, and in fact, a method used quite extensively today, is known as the lamp method, an elementary single-phase connection being shown in Fig. 1. In the illustration, number 1 and number 2 represent two single-phase generators, the leads of which are connected to the bus bars by switches and to a set of series lamps. From the nature of alternating current it is obvious that, as the phase of e.m.f.'s changes from that of exact coincidence to that of exact opposition, the flow of current through the lamps will vary from a minimum to a maximum.

In explanation of this, if the e.m.f. of number 1 reaches its maximum 180 deg. or half a cycle before the e.m.f. of number 2 reaches its maximum value, the current will flow through the lamps, causing them to burn. If, however, the e.m.f. of number 1 reaches its maximum positive or negative value at the same time that the e.m.f. of number 2 reaches its maximum positive or negative value, the two e.m.f.'s will be in phase and no current will flow through the lamps, hence they will not burn; and any intermediate values will result in a corresponding change in the brilliancy of the lamps. Thus, by carefully following the lamp pulsations, the machines can be brought in synchronism.

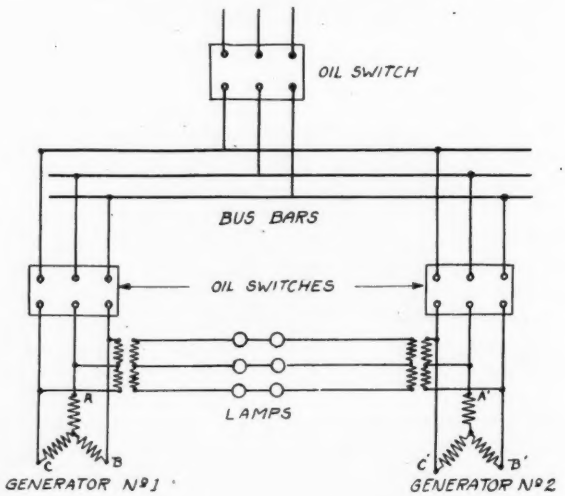



FIG. 2. METHOD OF SYNCHRONIZING 3-PHASE MACHINES WITH LAMPS

This method of synchronizing is very satisfactory, if the machines are of practically the same speed, and the method of synchronizing with a dark lamp is used, as the period of darkness, that is, complete darkness, is much shorter than the period of brightness. The lamp method is very unsatisfactory, however, either with a bright or dark lamp, if, for instance, you are trying to synchronize a 3600-r.p.m. turbine with a slow-speed engine. This is bad enough sometimes even with a synchroscope, as the reciprocating effect of the engine will cause the pointer of the synchroscope to be very uneven, that is, the rotation of the pointer will not be as uniform as it should be, and if the instrument is not very sensitive the pointer will apparently stick at certain points, usually at the top and bottom, and about nine

*General Superintendent, Eastern Minnesota Power Co.

times out of 10 when you close the paralleling switch, you will give the machines quite a jolt.

Figure 2 illustrates a method of phasing out three-phase generators with lamps, and the procedure to be followed out when using this method, with either machine in operation, is as follows: bring other machine up to speed, close the field switch, and adjust the exciting current until the voltage is approximately the same as the other machine and note whether the lamps are all bright and dark simultaneously; if so, the machines are in phase, but if not, it will be necessary to interchange any two of the leads at one of the machines, after which the lamps will all be bright and dark simultaneously, and the machines are in phase.

Figure 3 illustrates another method of phasing out machines with lamps, using two sets of lamps instead of three, as illustrated in Fig. 2. When using this method, first make the connections as shown, and if, for instance, number 1 machine is in operation and connected to the bus bars, disconnect the leads from generator number 2, and close switch number 2. Change the connections, if necessary, so that both sets of lamps will be the same when indicating synchronism, open the paralleling switch, reconnect the leads to generator number 2, and bring it up to speed and voltage. Then observe the two sets of lamps. If both sets are bright and both sets are dark at the same time, the machines are in phase, and the connections are correct for paralleling the generators when the lamps are dark; however, if the pulsations of the lamps are not together, that is, if one set is bright when the other set is dark, interchange any two leads of one machine and test out the synchronizing connections again, changing them if necessary, so that they are the same when indicating synchronism. They will now be found to pulsate together and the machines may be paralleled when synchronism is indicated. The object of opening the leads at one machine and closing the paralleling switch is that when this is done, both primaries are connected through the switches to one machine, the lamps will be in the same condition as when the main paralleling switches are open and both generators are in phase.

If the lamps burn brightly and it is desired that they be dark for an indication of synchronism, the connection of one of the primaries or one of the secondaries should be reversed.

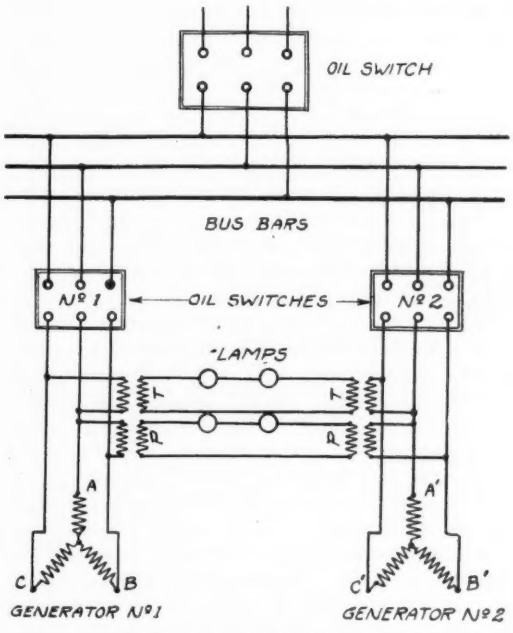



FIG. 3. PHASING OUT 3-PHASE MACHINES WITH LAMPS IN TWO WIRES ONLY

### Induction Motor Method

By referring to Fig. 4, it will be noted that the two generators are connected through a triple-pole, double-throw switch to an induction motor. The procedure to be followed in phasing-out by this method is first to have one machine in operation, and we will assume this to be number 2. Bring number 1 machine up to speed and voltage, close the switch connecting the motor to either machine and note the direction of rotation of the motor. Then open the switch, allow the motor to come to rest, and then close the switch to the other machine and if the direction of rotation is the same as before the machines are in phase, and it is only necessary to bring them into synchronism when the paralleling switches may be closed. This, of course, cannot be determined by the motor. If the direction of rotation of the motor is in an opposite direction from that at first, it is only necessary to interchange any two of the leads at either machine, after which they will be in phase.

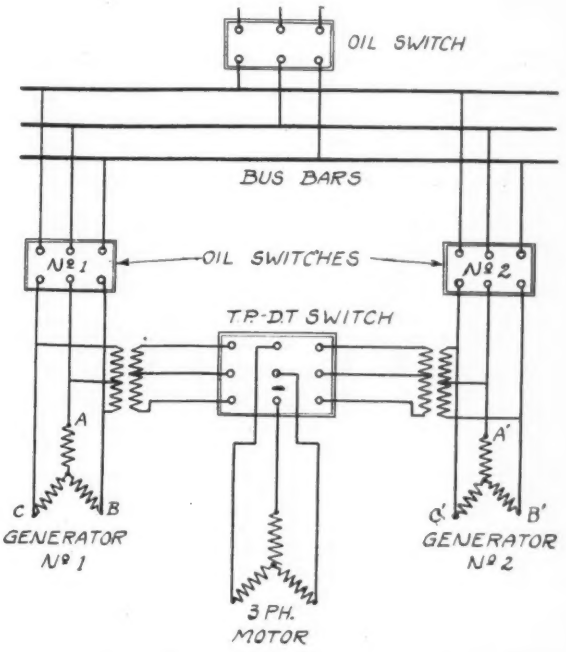



FIG. 4. METHOD OF PHASING OUT 3-PHASE ALTERNATORS WITH 3-PHASE MOTOR

In order that the method of phasing-out machines by the induction motor method may be more fully understood, I have constructed three diagrams to show that the same phase rotation can be obtained with different connections.

Diagram (A), Fig. 5, shows two three-phase machines connected to a three-phase motor, through a

triple-pole, double-throw switch, the same as shown in Fig. 4, except that arrows have been added to indicate the instantaneous direction of the flow of the current, or what is equivalent to the same thing, the phase rotation. It is to be noted that with the switch closed to either machine, the phase rotation through the motor windings is the same, the direction of rotation of the motor is the same and it is very clear that the machines are in phase. Now referring to diagram (B) where it will be seen that A and B leads from number 1 machine have been interchanged, at the switch, the phase rotation from number 1 machine being indicated by the dotted arrows placed on the motor windings, and the phase rotation from number 2 machine being indicated by the full line arrows placed on the motor windings. The illustration shows that the direction of rotation of the motor will be in an opposite direction when operated from one machine from that when operated from the other. This is what occurs when the leads are interchanged at a

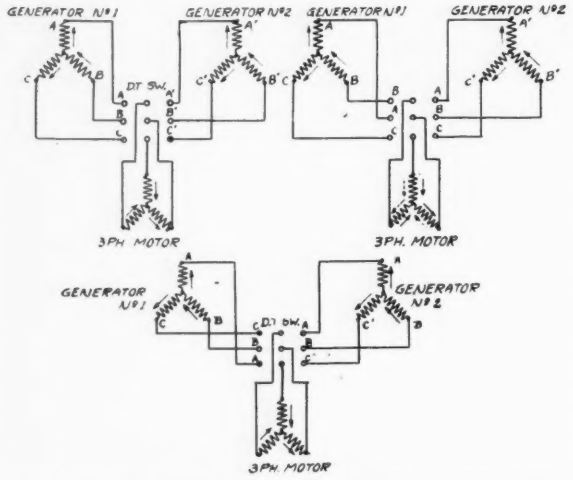



FIG. 5. DIAGRAM SHOWING PHASE ROTATION WITH DIFFERENT CONNECTIONS

motor to reverse the direction of rotation. That is, when two of the leads are interchanged. Diagram (B) illustrates very clearly that with this connection, the machines are not in phase. Diagram (C), Fig. 5, illustrates a condition of leads A and C from number 1 machine being interchanged, which is a different connection from that illustrated in diagram A, and it is to be noted that the machines are again in phase.

## EXCITATION

IN THESE days of high fuel prices, it is necessary that everything possible be done to increase plant economy, and several small items of saving soon amount to a considerable amount. One of the items of loss in the average power plant is the excitation loss. It is a very common thing to walk into a plant and find no voltmeter or pilot lamp on the exciter, and if there is you will probably find the exciter voltage up around 125 v., with probably two-thirds or more of the generator field resistance cut in, in order to hold the generator voltage down to the prescribed limit. No exciter should be allowed to operate without some means of knowing what the approximate exciter voltage is, and one of the most satisfactory methods is to have a small lamp connected across the exciter leads, as by this lamp, any excessive voltage can be noticed at a distance and adjustments made.

Losses in generator field rheostats range from about 500 watts up to 5 kw. or more, while the losses in exciter rheostats are very small. In order to prevent excessive excitation losses, the generator field resistance should be as near all cut out as possible, while the exciter resistance should be cut in sufficiently to maintain a proper generator voltage. It will generally be found that the most economical excitation will be obtained with the exciter voltage around 80 to 100 v.

If the excitation is checked up carefully, it will generally be found that quite a substantial saving can be made in a year's time, as the fuel costs per kw.-hr. for excitation will be in excess of that for the general station output.

In plants having a separate exciter for each machine, which is the average condition for the smaller and medium sized plants, it is convenient to have all of the exciter leads run to the switchboard, and in case the machines are of the same design, that is, all shunt wound or all compound wound, they may be connected to a common bus and all operated in parallel. If they are all shunt wound, it will not be necessary to have them connected with an equalizer, the only precaution being, to have their relative polarities connected to the same bus. If, however, they are all compound wound, it will be necessary to have them connected together with an equalizer wire, and this equalizer may be run directly between the machines or, it can be run to the switchboard and connected to an equalizer bus, either through a single-pole switch or through the center pole of a triple-pole switch. It is necessary that the equalizer wire have a lower resistance than the leads from either of the machines to the switchboard, otherwise, there is danger of current flowing from the bus bars back through the series field in an opposite direction, thus reversing the polarity of that particular machine.

In case of reversed polarity, which I have known to happen on several occasions, it is only necessary to raise the brushes from the commutator of the machine having a reversed polarity, cut all of the shunt field resistance in, close the switch connecting the exciter to the bus bars, and this will energize the shunt field, from the busses, thus correcting the polarity. Leave the switch closed for an instant, and then open very slowly. After this has been done, lower the brushes and start the machine, when it will be found that it will build up its voltage in the proper direction and may be then paralleled safely with the other machines.

It is quite often the case when plants are operating in parallel, that not enough attention is given to the voltage and power factor. For instance, one plant may have the voltage up to where it should be, while the power factor will be down around 60 or 70 per cent, when it will be found that some of the other plants will have a good power factor and the voltage down. This is a condition that should not be allowed to exist unless it is that one or more of the plants are operating as standby and merely carrying a light load or just floating on the line for the purpose of being able to pick up the load, in case of trouble, or for holding up the voltage of the system.

In the operation of alternators in parallel, unless all of the machines are of the same wave form and characteristics, there will be more or less cross current flow-

ing between the machines, which has the same heating effect on the windings as if this current were being consumed in useful work. For successful parallel operation, it is necessary that this cross current be kept to a minimum, and in order to do this it is necessary to give careful attention to the excitation. The excitation should be adjusted so the total current, as shown by the machine ammeters, will equal the current shown by the line ammeters. This is a condition that is practically impossible of attainment, due, as stated before, to the cross current flowing from one machine to the other, which, of course, shows on the machine ammeters but not on the line ammeters.

One of the important things to bear in mind is that the load cannot be shifted from one machine to the other, by increasing or decreasing the exciting current. This can only be accomplished by admitting more power to the prime mover of which it is desired to take the load, or decreasing the power to the other machine. This operation is usually performed by adjusting the governor.

Operation of alternators in parallel is a simple matter, and one that requires but little attention after the machines are thrown together and the field excitation adjusted.

Generators driven by steam turbines give the most satisfactory parallel operation, as turbines are usually more finely governed. If turbine driven generators are operated in parallel with engine driven generators, there will always be more or less fluctuation of the instrument pointers, due to the reciprocating effect of the engines, especially in the case of smaller sized units.

# Interpole vs. Non-Interpole Machines

THE SELECTION OF THE CORRECT MOTOR DEMANDS A THOROUGH UNDERSTANDING OF REQUIREMENTS. BY PHILIP G. BERNHOLZ

IN SELECTING direct current motors and generators, few customers understand the characteristics of interpole machines sufficiently well to make the best selection for meeting the various requirements encountered in the electrical field. The large manufacturers of motors and generators employ electrical engineers with electrical experience for their salesmen, as they realize the many problems and the importance of satisfying their customers by selling the right kind of a machine to them.

While the salesman understands his machine as should be the case with a good salesman, he often may not know the requirements to be met as well as the customer does and the latter after all, is the first to be well considered before selecting the machine. The customer is therefore often in a better position to know what he wants and could make a better selection than the salesman if he were sufficiently posted electrically. Besides he would feel better if he could select his own wants instead of feeling skeptical that something just as good or merely something that would do his work was sold to him instead of what he really should have had.

### NON-INTERPOLE MOTORS HAVE USEFUL FIELD

MACHINES WITHOUT interpoles have a useful field as well as machines with interpoles and of course they are a little simpler to connect up for the ordinary electrician. For generators the problem is much more simple than with motors, as the speed is generally quite constant with full or nearly full field and the main question is therefore commutation. Commutation troubles depend upon the brushes being kept in the neutral position. The neutral position on a generator without interpoles shifts forward for every increase in load while the amount of shift depends upon the stiffness of the field at the poleshoes. Such generators should therefore be operated with well-saturated field poles and on loads that are fairly steady, brushes being shifted by the operator from time to time for the best condition.

### NO SHIFTING OF NEUTRAL WITH INTERPOLE MOTORS

WITH AN interpole generator, if of a good make properly tested and adjusted, there should be no shifting of the neutral for any variation in load. It naturally requires much closer adjustment and longer testing and the machine is more complicated; but once right it is always right and, where the load varies considerably, it really is the only machine that should be considered.

With motors the question of selecting the right machine is a much wider question, as motors are required to operate under such various conditions, some of which are very hard to meet in any really satisfactory way. On a motor without interpoles the neutral shifts backward with any increase in load and as motors are often required for reversing duty, brush shifting becomes impossible. Besides motors are very often required to operate over a wide range of speed, which is now nearly always accomplished by weakening the field. Although some speed regulation can be obtained in that way on a small machine without serious results, the field of real speed regulation by this method belongs entirely to the interpole machine. Interpole machines can be operated quite satisfactorily at speeds of three and four times their low or full field speed without any shifting of brushes or bad commutation; however, if the machine is not well adjusted, it may become unstable at the higher speed and tend to race. Interpoles are used on all three types of direct current machines—series, shunt and compound. The addition of interpoles does not complicate the external connections of a machine in any way.

### WHERE, AND WHERE NOT TO USE INTERPOLES

IT MIGHT then be said that for a steady lighting load or other steady power up to a few hundred kw., a generator without interpoles might be chosen, but if more than a few hundred kw., even if the load were quite steady, an interpole machine would be more satisfactory. Where elevators or other machinery of that kind are on the line, an interpole generator should be chosen. Motors for variable speed drive, such as used for driving lathes, etc., should be interpole down to a few hp. Motors driving machinery where the motor requires frequent reversing or where the power varies much should also be interpole down to a few hp. Motors driving a fairly steady load at a steady speed may be without interpoles up to, say, 50 hp. or even larger. On 5 to 25-hp. motors for ordinary power requirements, simplicity and cost may overbalance the advantages of interpoles. On smaller than 5 hp. motors, the advantages of interpoles are not so great and therefore they are used only more or less special requirements.

# Motor Applications in the Woodworking Industry

HIGH SPEED REQUIREMENTS AND COMPLEX DESIGN OF MACHINES MAKE MOTOR DRIVE PARTICULARLY ADAPTABLE. BY GORDON FOX

MACHINERY USED in planing mills and other woodworking establishments is of varied character. A review of individual machines is hardly feasible, but general considerations and practices together with a few typical applications may be discussed to advantage.

Woodworking tools might be broadly classified as either sawing or cutting devices. Circular saws and band saws predominate in their field. Circular saws may be cross cut, as for cutoff saws or swing saws, or they may be used for ripping. Band saws are used

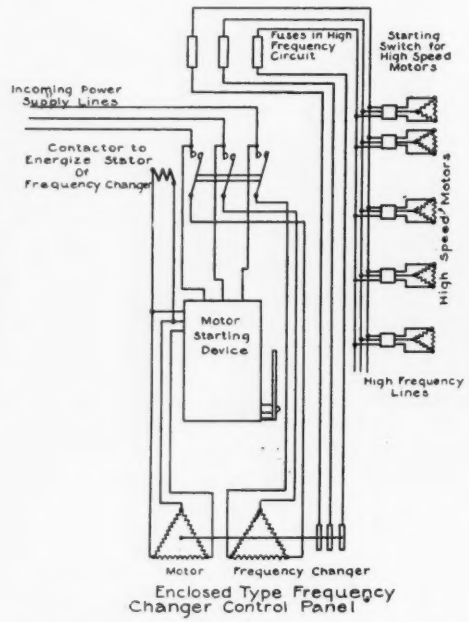

Fuses in High Frequency Circuit
Starting Switch for High Speed Motors
Incoming Power Supply Lines
Contactor to Energize Stator Of Frequency Changer
High Speed Motors
Motor Starting Device
High Frequency Lines
Motor
Frequency Changer
Enclosed Type Frequency Changer Control Panel

FIG. 1. CONNECTIONS OF INDUCTION FREQUENCY CHANGER FOR HIGH SPEED MOTORS

principally as resaws and scroll saws. Jig saws having a reciprocating motion are less common. Cutting tools may be considered as including surfacing devices such as planers and jointers. They also include tools which cut to form such as matchers and shapers.

Woodworking machines may be further distinguished as being either hand-fed or power-fed. In a hand-fed machine, as the name implies, the stock is fed to the tool by the operator and he determines the rate of cutting. Among this class are included shapers, boring machines, hand-fed rip and cutoff saws, lathes, hand feed jointers, belt and disc sanders, scroll saws and jig saws. The stock is entered to a power-fed machine by an operator but the rate of cutting is determined by the machine. Machines of this type are usually equipped with a pinch roll which is driven and which, in turn, feeds the stock past the cutting tool. Among the more common equipments of this type may be mentioned planers and matchers, moulders, stickers, self-feed rip saws, scraping machines, resaws and power feed tenoners.

From the foregoing general description of woodworking machines it may be seen that power may be required for either or both of two purposes; namely, to drive the cutting tools and to handle and feed the stock through the machine. All that is required on a hand feed saw or jointer, for instance, is a drive for the cutting unit. Power fed tools require drives for the cutting head and for the feed device. Many machines are equipped with two or more cutting heads for performing two or more operations.

### ADVANTAGE OF MOTOR DRIVES

HAVING IN mind a general conception of woodworking machines, we may well consider next the special advantages of motor drive as applied to these tools. The application should always be such as to realize, as far as feasible, the advantages promised. The principal benefit of motor drive arises in the ability to maintain speeds under load. Woodworking machines

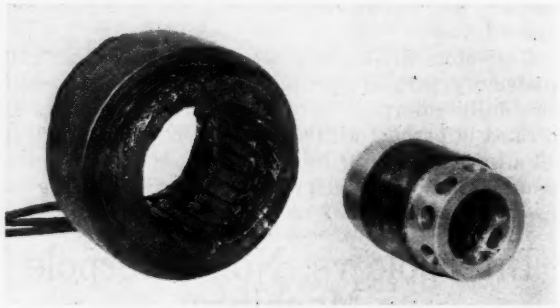


FIG. 2. PARTS OF INDUCTION MOTOR RATED AT 1 HP., 12,000 R.P.M. 200 CYCLES, 110 V.

are, for the most part, high speed equipments. A second important consideration in securing maximum output is the handling of materials and feeding the machines. Individual motor drive permits the most advantageous placing of machines and leaves the space about them clear for passage.

Secondary to increased production is the saving in power effected through motor drives. Woodworking machines seldom operate at average loads anywhere near the maximum load. It is necessary, however, to provide power transmission equipment suitable for the maximum load ever imposed. Line shafting or belting must be large enough to handle loads much heavier than are normally transmitted. This results not only in high first cost, but also in increased friction losses, so that the power actually utilized at the tool may be less than that consumed in friction of transmission. Shafting and belt losses may be almost entirely eliminated by using motor drive. Individual motor drive permits the delivery of the maximum percentage at the driven tool of the total power generated. The load demand of woodworking tools depends upon a number of factors. The same machine, under different conditions, will require different amounts of power and take a different size motor. One of the important considerations is the kind of stock used. Soft woods require materially less power than harder woods for the same operation.

Another important consideration is the range of work for which a given machine is employed. It is quite unusual for woodworking machines to be utilized at all continuously upon the maximum duty of which they are capable. In factories turning out a large amount of one kind of work, machines are apt to be retained more regularly on one size of stock whereas, if the work is more of a jobbing nature, operation is apt to be more intermittent and load demand more varied.

In the matter of load demand very real distinction may be made between hand-fed and power-fed machines. In the former class the service is more or less intermittent, depending on the rate at which the operator feeds the stock. The load peaks are usually of short duration, the light load is comparatively low and the inherent overload capacity of the motors, particularly if of the induction type, is sufficient to carry the peaks. Hence liberal motoring is not necessary and even to be avoided. With power-fed machines, the work is usually fed as fast as it can be handled. The machine therefore works nearer its limit and the motor must be large enough to handle full demand continuously. Furthermore, the inherent friction of power feed machines is considerable so that the light load demand is higher. For these reasons power feed machines handling a given size of stock, require larger motors than hand feed machines for the same service. The increased output, however, causes the power consumption per unit of output to be no greater and often less than that of hand feed machines.

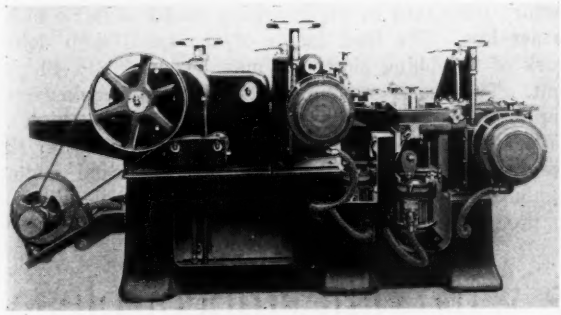


FIG. 3. FOUR-SIDE MOULDER WITH INDIVIDUAL DRIVE FOR EACH HEAD AND FEED

### Induction Motor Ideally Suited

An induction motor is almost ideally suited for driving the general run of woodworking machines. Its simplicity, reliability and ease of repair are, as usual, pronounced advantages. The absence of collectors on the squirrel cage motor is of benefit in eliminating the fire risk which is a consideration of some importance. The ability to carry heavy overloads of short duration without injury is of particular import as related to the widely fluctuating loads of many woodworking machines. The constant speed characteristics meet the requirements of nearly all woodworking tools. For these reasons alternating current is to be preferred wherever a choice is possible.

Sixty cycles is well adapted to the needs of this industry. The motor speeds available on this frequency fit nicely the drive requirements. Mention has been previously made of the desirability of elimination of belts as far as possible. The high speeds common to many wood-working machines place gear drives at a disadvantage and render necessary the use of rawhide, fiber or cloth gears. Direct connection of the motor to the active member is particularly desirable for many woodworking tools. As examples of this practice may be cited the use of 1200-r.p.m. and 1800-r.p.m. motors direct connected to saw arbors; small motors in lathe headstocks; and 900-r.p.m. and 1200-r.p.m. motors coupled to the countershaft of four-side moulders. The use of 3600-r.p.m. motors direct connected to cutting heads of planers and jointers is particularly advantageous.

### Frequency Changers for High Speeds

Because of the desirability of direct connection of the motor to the tool, a somewhat special system has been developed, particularly suited for some woodworking equipments. The purpose of this system is to make possible the use of motors having speeds even higher than 3600 r.p.m. This speed is the maximum attainable in a 60-cycle induction motor as a motor of this speed has but one pair of poles, an irreducible minimum. To render available still higher speeds, a higher frequency is necessary. For supplying the desired high frequencies there are available "induction frequency changers." The frequency changer proper is practically a wound rotor induction motor in design. This is driven by a squirrel cage motor, the two units comprising a motor generator set. The stator winding of the frequency changer is connected to the alternating current system. The rotor of this unit is driven in a direction opposite to the rotation of its revolving field. A frequency is thereby generated in the rotor equal to the frequency of the excitation circuit plus that due to the reversed rotation of the rotor. This combination may be expressed by the formula:

$$fr = \frac{\text{r.p.m.} \times (P \div 2)}{60} + fs$$

Where fr = resulting rotor frequency
fs = line frequency impressed on stator
P = No poles of frequency changer.

The high frequency side of these machines is always three-phase. The voltage of the high frequency power depends upon the frequency generated because standard machines are utilized, being merely driven at different speeds to generate different frequencies. As a consequence of the different speeds, with given windings, the generated voltage values differ. A portion of the

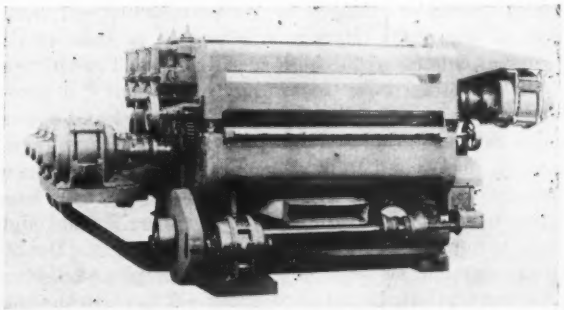


FIG. 4. SIX-DRUM SANDER WITH INDIVIDUAL MOTOR DRIVE

input to the frequency converter is represented by electrical power delivered to its stator winding; the balance is mechanical power at the driven shaft. The relative proportions depend upon the relation of line frequency to generated frequency. The wider the difference, the greater the mechanical input component. The overall efficiency of one of these frequency converter sets is about 90 per cent. They are built to deliver frequencies up to 300 cycles per second at voltages ranging from 100 to 360 v. Figure 1 is a simple diagram of connections showing the application of the induction frequency changer.

Motors for operation on these high frequency systems are of the squirrel cage type, usually two-pole. The electrical members are shown in Fig. 2. These parts are intended to be built into the design of the driven machine. These motors are available for speeds up to 18,000 r.p.m. corresponding to 300 cycles, but the sizes at high speeds are limited by the permissible peripheral speed of the rotor. Particular attention is given to the matter of balance of the high speed rotors. The voltages of these motors differ according to frequency, a given motor being suited to a range of frequencies and speeds and a corresponding range of voltages. These voltages, in turn, correspond to those generated by the frequency changer for the stated frequency. The motors thus have approximately a constant current rating. The high speed motors are available in sizes up to 25 hp. Double throw starting switches are usually employed. Magnetic starters can be obtained arranged to start the several motors on a given machine in sequence from a single control station. This is a convenient arrangement and incidentally minimizes line disturbances. The starting current and torque relations are similar to those of 60-cycle motors. Because of the inertia factor of high speed drives, the starting periods may be of considerable duration. The normal full load slip of these motors is 5 to 7 per cent. Motors with higher resistance rotors may be obtained, having 8 to 10 per cent slip and developing higher starting torques. These motors may be used where starting torque is a determining factor and where the motor is ordinarily not fully loaded.

There are few machines which utilize direct connected motors of both standard and high frequency types. Figure 3 shows a four-side moulding machine, the cutting heads of which are driven by individual 3600-r.p.m., 60-cycle motors, two of them being vertical units. Figure 4 shows a six-drum sander having individual motor drives for the drums. The feed rolls are driven by the motors below. It may be noted that the fact that motors suitable for direct drive are normally of high speed and consequent small dimensions favors this method of application.

In closing, it should be remarked that, due to the large number of small induction motors installed, together with the intermittent operation and loading and the frequent usage of machines on light work, the load factor of the load in woodworking plants is liable to be rather low. The load factor of the small shop doing work of a jobbing character may be but 30 to 40 per cent. The factor working all equipment regularly on duplicate production may have a load factor as high as 75 per cent. The power factor is likely to be on the order of 70 per cent. The use of individual motors combined with the practice of shutting down units not in production is of some benefit in this connection.

# Measuring Temperatures with Thermocouples*

A Discussion of the Practical Applications and Limitations of Thermocouples for Temperature Measurement. By Irving B. Smith

BECAUSE OF THE fact that the limiting factor of safe operation in central stations is temperature, it is not strange that we find temperature measurements becoming increasingly important in the control and operation of power plant equipment. This fact, together with the demand for higher efficiency has brought about a demand for a means of determining temperatures over a wide range, the upper limit of which often excludes the use of mercurial or other expansion types of thermometers. Moreover, a permanent and continuous record of temperature may be necessary or it may be desirable automatically to control or limit the temperature of some apparatus or process. The thermocouple has definitely established itself as a convenient and precise instrument for such purposes. We wish, therefore, to consider some of the difficulties to be overcome and precautions to be taken in applying the thermocouple to such measurements.

From the viewpoint of the station engineer, we may conveniently classify temperature measurements under the following heads: 1. Feed water, 2. Boiler water, 3. Economizer, 4. Flue gas, 5. Superheated steam, 6. Bearings, 7. Generator windings, 8. Transformer windings.

*Abstract of a paper delivered at the Midwinter Convention of the A. I. E. E., February, 1923.

Before considering these applications, it is desirable to refer briefly to the sources of error that may arise in making temperature measurements with the thermocouple. They may be outlined as residing in the following:

1. Thermocouple calibration, 2. Instrument calibration, 3. Thermocouple circuit, 4. Radiation losses, 5. Conduction losses, 6. Parasitic e.m.f., 7. Temperature lag, 8. Cold junction temperature, 9. Measured temperature variable.

## I. Thermocouple Calibration

A thermocouple may be in error because its original calibration was wrong or because its calibration may have changed from use.

For temperature measurements below 320 deg. C., it is customary to use couples of copper and constantan. They may be relied upon to remain constant to within 0.5 deg. C. Even up to 500 deg. C., they will be found accurate and reliable although the copper element oxidizes rapidly at such a high temperature and therefore must be renewed frequently.

Up to 320 deg. C. thermocouples may be checked against a mercurial thermometer by placing both in a well stirred oil bath keeping them close together but away from the sides or bottom of the bath. Practically

the only difficulty is to obtain a reliable and accurate mercury thermometer available up to 320 deg. C. When employing a mercurial thermometer it is necessary to avoid stem errors by immersing in the bath just up to the point where it was immersed at the time of calibrating or by applying stem corrections. Failure to do this may result in errors as great as 14 deg. C. at 320 deg. C. and errors proportionately great at lower temperatures. Nearly as large errors may also result from using mercurial thermometers that have not been properly annealed. In view of these facts, the writer considers the mercurial thermometer less desirable as a standard than a thermocouple. It is found both convenient and reliable to reserve two or three copper constantan couples of about No. 22 B. & S.

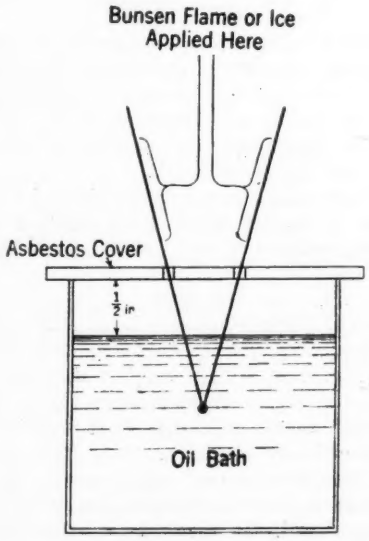



FIG. 1. METHOD OF CHECKING UP ERRORS DUE TO VARIATION OF TEMPERATURE OF EMERGENT PORTION OF COUPLES

gage wire as standards, sending them occasionally to the Bureau of Standards for check and using them only for the purpose of checking working thermocouples. Checking one couple against another is easily and quickly accomplished. No particular precaution need be observed to avoid errors due to the cooling effect of the emergent portion of the couples. The writer immersed fine wire couples to a depth of about ½ in. in a bath of mercury which was stirred and electrically heated. The couple wires were drawn down to diameters varying from 0.013 in. to 0.031 in. While the mercury was heated to 149 deg. C. and then cooled, a continuous record was made of the differences in temperature registered by the various couples. They differed at no time by so much as 0.25 deg. C. This difference was not increased measurably by maintaining the bath at a constant temperature and heating the extended wires to a red heat. Nor was it increased by placing the wires in ice. A similar procedure using an oil bath but immersing the couples to a depth of 6 in. produced like results. As indicated in Fig. 1, an oil bath had a light asbestos sheet cover ½ in. above the oil and the thermocouple wires extended through the cover. Heating or cooling the wires was done just above the cover. It appears, therefore, that from the standpoint of cooling the conduction along the couple wires, there need be no fear of errors of any appreciable magnitude when the couple wires are of No. 22 B. & S. gage or smaller, provided the hot junction is in intimate contact with the bath. When, however, the couples are of heavy wire or are not intimately in contact with the bath, error from

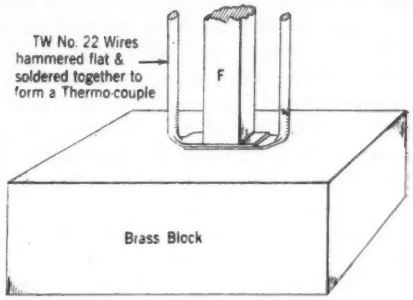



FIG. 2. EXPERIMENT TO SHOW EFFECT OF PRESSURE OF CONTACT UPON ACCURACY OF COUPLE

this source may be considerable in magnitude as well as uncertain in amount.

While twists and sharp bends in the couples set up strains which may be the seat of parasitic e.m.f., such disturbances are too small to be a source of trouble at temperatures no higher than those to be measured with copper-constantan couples when the wires of which the couples are made are small.

In checking a thermocouple, it is sufficient, if a potentiometer method of measurement is employed, simply to twist the couple wires together, no precaution such as soldering or welding the wires being necessary. In fact, couples are often used in actual tests by merely twisting them together. While this procedure would be unsafe when measuring with a millivoltmeter, it is not conducive to error when using a potentiometer type of indicator.

For measuring temperatures above 320 deg. C. it is usual to employ a couple made of iron and constantan. These couples are serviceable up to 1000 deg. C. Here also care must be taken to insure that the couple is in correct calibration. A fairly large error may result from the use of iron wire not standard.

## II. Instrument Calibration

One of the most satisfactory methods of determining the electromotive force of a thermocouple is by means of a potentiometer. A potentiometer may be checked independently of its leads whether it reads directly in temperature or is calibrated in millivolts since the leads do not enter into the calibration. As a rule a check on the accuracy of the standard cell is all that is needed with a potentiometer to warrant one in relying upon the correctness of the instrument as a whole.

## III. Thermocouple Circuit

Any change in the resistance of the thermocouple circuit causes an error in a millivoltmeter type of pyrometer or thermometer proportional to such change. The circuit resistance may vary due to changes in temperature or oxidation of the leads or due to changes in

the material, size or length of the leads. Oxidation of the hot junction also may greatly change the resistance of the circuit. With modern types of millivoltmeters of high resistance the error due to changes in lead temperature may be kept low but this source of error limits the length of leads which may be used.

With instruments of the potentiometer type, no error results from the above sources excepting a small one arising from a change in sensitivity of the instrument due to a change in resistance of the circuit. If, for example, for some reason, perhaps oxidation of the hot junction of a couple, the resistance of the circuit has doubled, then a potentiometer capable at first of balancing to say 0.5 deg. C. would now be of such sensitivity as to balance to 1 deg. C., thereby introducing an uncertainty of 1 deg. C. in the measurement from this cause.

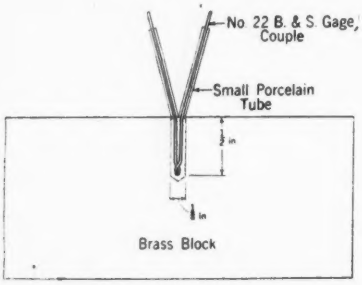



FIG. 3. COUPLE INSERTED WITH A BLOCK OF BRASS

On the other hand a millivoltmeter would show an error at say 100 deg. C of nearly 50 deg. C.

## IV. Radiation Losses

Errors due to radiation may be positive or negative, depending upon whether the radiant energy is being transferred to or from the thermocouple. The errors are reduced by making the couple of fine wires and by not enclosing them in protecting tubes

## V. Conduction Losses

In measuring temperature with a thermocouple there is, in general, an error introduced due to the fact that the wires of which the couple is composed conduct heat to or from the hot junction. With a good thermal connection between a couple and a good heat conducting solid or liquid, no trouble is experienced with couples of small dimensions. Under other conditions, however, large errors may result and are often difficult of elimination or estimate. One might naturally think that a couple of wires so fine as 0.031 in. diameter (No. 22 B. & S. gage) inserted in a fairly deep hole in a porcelain block would closely assume the temperature of the porcelain. But this is by no means true even when the block is of some good conducting material such as metal. A No. 22 gage couple was hammered flat and placed in intimate contact with a brass block at a temperature of 150 deg. C. See Fig. 2. The couple registered 16 deg. C. low. Pressing the couple firmly against the brass block with a strip of hard fibre, *F*, Fig. 2, resulted in reducing the error to 8 deg. C. This could be reduced still more by using a plastic insulator covering the surface of the couple and the sides but there is always the danger that such a procedure will cause a change in the heat distribution and to that extent give an incorrect measurement. A similar couple with ends well twisted but not flattened and inserted to a depth of ½ in. in a ⅛-in. hole in the block registered 11 deg. C. low. Figure 3 indicates the arrangement. The couple made contact with the bottom of the hole. Porcelain insulating tubes slipped over the thermocouple wires failed to reduce the error below 8 deg. C. When the hole was filled with mercury, however, the couple registered correctly to within 0.2 deg. C. A couple of small dimensions embedded in the material, preferably by peening each couple wire separately into a hole in the body whose temperature is to be measured, is the best approach to ideal conditions and in many cases is a practical means of eliminating conduction errors. Under such conditions conduction errors are negligible.

## VI. Parasitic E.M.F.

Use of iron constantan thermocouples at high temperatures creates a region of inhomogeneity where the steepest temperature gradient exists. This becomes the seat of local e.m.f. To avoid error from this source in checking or in future use, the couples should be immersed to at least an equal depth.

Parasitic currents arising from bends and twists are small enough to neglect when using small wires and measuring temperatures of but a few hundred degrees C.

## VII. Lag

In the use of thermocouples it is sometimes required that they be protected from contact with their surroundings by lagging them. This lagging may be for the purpose of protecting them against the chemical action of gases, molten metals or liquids or it may be for the purpose of electrically insulating them from their surroundings. The errors introduced thereby may be the result of radiation losses or simply due to the thermal resistance introduced. In the latter case the losses due to conduction are accentuated.

## VIII. Cold Junction Temperature

Perhaps the one source of error often referred to is that arising from the temperature of the cold junction of the thermocouple. It is now well understood that if a thermocouple temperature indicator is calibrated when the cold junction is at one temperature, it will not read correctly when the cold junction is at another temperature unless the instrument is so constructed as to eliminate error from this source. It is not correct, as some makers have assumed, to add to the instrument reading the excess or deficit of cold junction temperature over the calibrated value. The error from this procedure is not large when measuring temperatures of but a few hundred degrees C. By far the best way, however, is to employ an instrument having a correct automatic cold junction compensator.

## IX. Measured Temperature Variable

When the measured temperature is varying it is perhaps incorrect to attribute the error to the thermocouple but a consideration of the thermal couple design and location will offer a means for lessening any error from this cause. Cases have arisen where lag in the couple has been conducive to better results by offering an average temperature more nearly representative of the mean than would otherwise be secured. Where a

recording instrument is employed it may often be so adjusted as to damp out many variations and secure a record more representative and useful through being less subject to constant variation. And where a control mechanism is in use such lagging of the recorder or damping out of its motion may be essential for proper control.

### Classification of Temperature Measurement

#### I. Feed Water

Determination of feed water temperatures is usually made with a mercurial or other type of expansion thermometer. The mercury thermometer placed in a mercury or oil well is in general a sufficiently accurate method of measurement but it often entails placing the thermometer in a more or less inaccessible place and does not permit of recording such temperatures. If a record is desired or if a distant indication is deemed necessary, the thermocouple will be found convenient. For this and similar applications, a thermocouple has been developed which is capable of withstanding the boiler pressure and convenient to install. When supplied with an automatic cold junction compensator it leaves nothing to be desired in the way of reliability and accuracy, convenience of installation, and ability to have indications or records or both at distant points. This type of thermocouple is in design quite similar to a gas engine spark plug. As indicated in Fig. 4, it is so constructed with tapered and insulated leads that the internal pressure acts to prevent rather than produce leaks.

#### II. Boiler Water

This problem is similar to that of determining feed water temperatures but in this case we have to contend with both high temperatures and high pressure. The same type of thermocouple plug has been found effective. The plug insulation is of mica and as stated before, the design is such as to preclude the likelihood of leaks starting due to the pressure and temperature to which the plugs are subjected. In fact, due to improper workmanship some plugs of this type when they were first being experimentally produced did leak when first installed. The temperature and pressure to which they were subjected soon closed up the leak. It has been found practical and safe to tap such plugs directly into a boiler.

#### III. Economizer

The determination of the temperature of the gases entering and leaving economizers has been made by means of thermocouples arranged in series and so disposed as to secure an approximation to the average temperature of the gas. In this case the various cold junctions are brought out to a convenient point where a compensator is applied.

When such couples are placed both before and after the economizer a double curve drawing recorder may be employed indicating at each instant the temperature of the entering gas, the temperature of the exit gas and the drop in temperature through the economizer.

#### IV. Flue Gas

A continuous record of flue gas temperatures may be required or it may be desired to control some other element of operation automatically in terms of flue gas temperature. The thermocouple controller recorder offers a means of accomplishing either or both results.

Kreisinger in Bulletin No. 145 of the Bureau of Mines calls attention to the fact that the major error in the determination of flue gas temperatures is that due to the radiation from the couple to its cooler surroundings unless precautions are taken to prevent such error.

In the last pass of the boiler or in the down-take the error is always in the direction indicating temperatures lower than actual, owing to the fact that the tubes in the last pass are at a much lower temperature than the gases. For this reason the couple radiates to the tubes and is therefore lowered in temperature. Kreisinger pertinently calls attention to two points: first, that the degree of accuracy of gas temperature measurements depends more upon the judgment of the user of the instrument than upon its correct calibration and second, because an instrument is correctly calibrated, the readings are too often assumed to indicate accurately the temperature of the gas.

#### V. Superheated Steam

Because of its rapid response to changes in temperature, the thermocouple has found an unexpected application in connection with the measurement of temperature of superheated steam. If water is carried along with the steam and strikes the thermocouple it lowers its temperature suddenly. A continuous record of the thermocouple temperature, therefore, shows sudden breaks, the cause of which is readily recognized. The application to this service was primarily for the purpose of determining the degree of superheat in making acceptance tests of superheaters. It proved very useful in this respect in that it was immediately responsive to any changes due to change in load and was free from suspicion of error due to lead conduction.

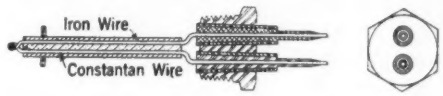



Fig. 4. Plug type couple for temperature measurement under high pressures

#### VI. Bearings

Thermocouples embedded in bearings operate under conditions that insure reliable measurements provided care is taken to secure proper electrical insulation in order that stray currents may not produce errors.

It is practical to keep not only a continuous record of bearing temperatures but to have the recorder furnish a light or bell signal if the temperature rises above a safe limit.

#### VII. Generator Windings

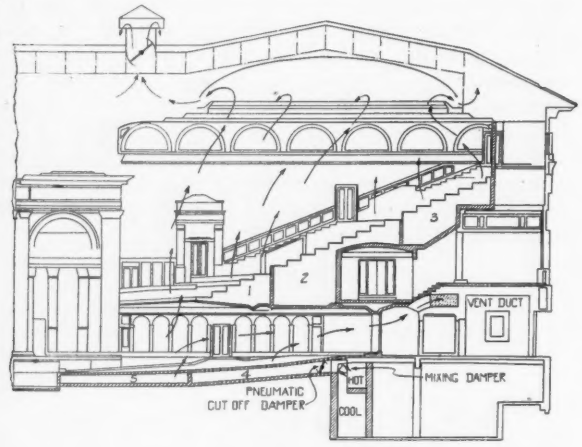
After a careful analysis of the design of a machine has indicated the probable hottest region, there remains the problem of so locating the couple as to enable the temperature of the copper at this point to be determined.

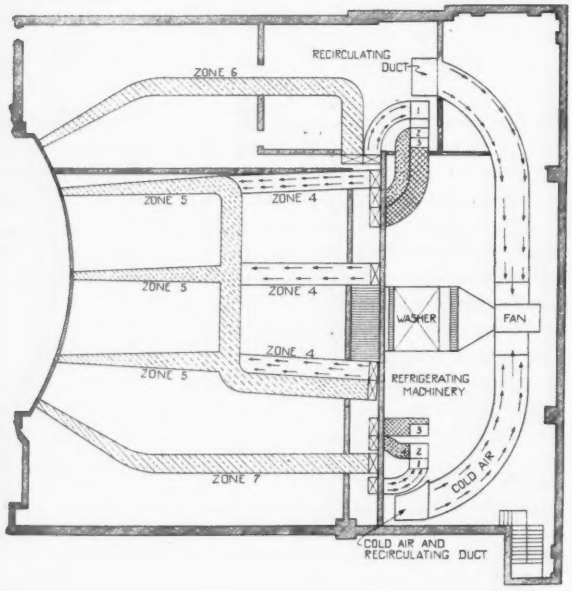
In service, the couple has to be placed outside the insulation, therefore a correction is necessary for the temperature drop through the insulation. Standard corrections for this drop have been adopted in the standardization rules of the A. I. E. E.

# Symposium on Theatre Heating and Ventilation

## Illinois Chapter of the American Society of Heating and Ventilating Engineers Discuss Various Systems of Air Distribution in Theatres

VARIOUS METHODS of providing for the heating and ventilation of a theatre were presented at the meeting of the Illinois chapter of the American Society of Heating and Ventilating Engineers at the Chicago Engineers Club on March 12 by H. D. Allen, heating engineer, of Chicago; E. P. Heckel, of the Carrier Engr. Corp.; G. H. Blanding, of the Johnson Service Co.; and E. V. Hill, formerly of the Chicago Department of Health. Each speaker was provided with a set of drawings of a modern moving picture theatre of 2000 seating capacity and on these drawings each indicated his method of installing heating and ventilating equipment.




PLAN OF THEATRE UNDER DISCUSSION, SHOWING ZONING ARRANGEMENT

Mr. Allen, president of the section, opened the discussion by describing the layout of the building as it was installed, according to the conventional design, employing the usual preheater, air washer, after heater, refrigerating apparatus, and plenum chamber distributor through mushroom heads under the seats, recirculating system and roof exhausters.

Dr. Hill, who conducted the meeting, characterized this presentation as a simple melody compared to which Mr. Heckel's paper was to be Wagnerian opera; Mr. Blanding's, ecclesiastical; and his own, jazz music.

Mr. Heckel's paper dealt largely with the system of downward introduction of the air as opposed to the conventional mushroom method. He considered also quantities involved to secure certain desirable weather conditions.

Ventilation of the theatre, or any other enclosure, is in itself a comparatively simple problem, if you consider ventilation merely a matter of displacing theatre air with a large or small volume of outside air by mechanical means. The cooling of a theatre is also rather simple when incorporated with ventilation and when theatre temperatures (dry bulb alone) are considered without respect to relative humidities or resultant wet bulb temperatures, or when the economical operation of the theatre refrigeration and ventilation system is considered a matter of no real importance.

Broadly speaking, what is to be considered when we think of theatre ventilation and cooling? That subject in itself represents money spent for mechanical equipment for the assurance of the comfort of the patrons while in the theatre. I believe we should consider of paramount importance all of the following factors, any two of which, if omitted in such consideration, would not permit maximum comfort conditions commensurate with economy in the operation of such equipment. We like to think of theatre ventilation and cooling as comprising the following:

1. Maintaining dry bulb temperature in the theatre with some respect to out-door temperatures.
2. Maintaining a uniform wet bulb temperature with respect to the dry bulb temperature.
3. Providing good air circulation, or air movement.
4. Providing proper air distribution to promote uniformity of air delivery without objectionable drafts and without subjecting the patrons to either warm or cold saturated air, to their discomfort.
5. Maintaining purity of air in circulation.

Some objectionable features of the conventional method of air distribution, namely, the mushroom method, might be enumerated as follows:

1. A system designed to deliver air directly underneath the seats from the cooling apparatus, whether it be from a spray type dehumidifier or bunker coils, without a recirculating air mixture or means of re-heating, proves objectionable in that saturated air delivered under the seats with temperatures that may range anywhere from 50 to 65 deg. during the refrigeration period.

2. Difficulty is involved in getting a uniform distribution of air delivery since low duct velocities are necessary in the supply and practically the only means for regulation or varying the quantity discharge by the different mushrooms is by the adjustment of the mush-

rooms themselves. In adjusting the mushrooms, varying the sizes of discharge openings, varies the velocities from the various mushrooms. Even though the volume of air may be varied, the results are obviously uncertain.

3. The mushroom delivery method has one objectionable feature which it may be considered important to eliminate. I question if any of us would refuse to recognize the fact that air delivered directly on the floor level in a horizontal plane, disturbs the floor dust and keeps it in more or less constant circulation.

4. With the mushroom delivery method, the temperature and humidity regulation is not as easily obtainable and positive as we believe it should be.

Air conditioning in the past has been directed largely to industrial lines where the requirements for definite and uniform temperature and humidity conditions are infinitely more exacting than with theatre cooling and ventilation, although relatively not more important. Why not profit from that experience? I believe I am correct in saying that in no case do we deliver air at floor level.

Of extreme importance, as I see it, is air distribution, but it is also necessary that the design of the apparatus be of proper proportion for specific temperatures and humidities with a simple yet positive means for control of both. I therefore prefer, wherever practical, the downward method of air delivery which reverses the conventional method of mushroom delivery to the method of mushroom exhaustion. The principal advantages of the overhead method, I believe, can be enumerated as follows:

1. Uniformity in air distribution as well as distribution of temperature and humidity, obviating objectionable drafts, which, by the overhead method, I believe, is more easily obtained.

2. The downward flow of air has the advantage of permitting the cool air delivered to be tempered before it reaches the breathing zone and this air comes direct to the occupants.

3. It permits of flexibility in operation, whether one or more units are used, by splitting up the theatre into separate air delivery zones, as well as separate air exhaust zones, each zone being taken care of independent of the other.

4. If the rear of the house is unoccupied, the apparatus for that particular portion need not be in operation. This applies to any other portion of the house as well.

5. It permits closer regulation of temperatures and humidities, as the automatic regulators are then placed in the exhaust or return air duct which air temperatures will give the average breathing zone conditions, which, after all, is what we are interested in.

Let us assume that we want to hold the theatre conditions at 80 deg. maximum temperature when outside is at a maximum of 95 deg. The theatre humidity conditions to be held at 55 per cent relative humidity, with wet bulb temperatures not exceeding 68 deg. This means a moisture content in theatre air of not more than 6.93 gr. per cu. ft., and which determines the dewpoint temperature of room air to be 62 deg. This fixes one condition and consideration that cannot be changed, and that is—regardless of the volume of air passed through the cooling apparatus and regardless of the type of cooling apparatus, that air passed through the cooling equipment must be cooled to at least a temperature of 62 deg. before it is delivered to the theatre. Why? Because it is necessary, first, to fix the moisture content of the air so that when this air heats up to 80 deg. (the theatre temperature selected), the moisture contained by the air will be 55 per cent of the amount that air at 80 deg. could hold, if saturated with moisture. Air at 80 deg. if saturated, would hold 10.934 gr. per cu. ft. Since we want 55 per cent relative humidity, the actual moisture contained in the 80-deg. air must be 55 per cent of 10.934 or 6.02 gr. To obtain this condition necessitates cooling the air and condensing out the excessive moisture contained in the entering air, down to 62 deg., at which saturated temperature, the air will hold only the requisite moisture necessary.

We are considering a 2000 seat house. How much air is to be delivered? How much is to be cooled? We know that regardless of what volume we select, we must cool the air passing through the dehumidifier to at least 62 deg. Some say 25 c.f.m. per occupant, all from outdoors. This would mean 50,000 c.f.m. cooled to 62 deg. What does this mean in refrigeration load? What is the B.t.u. load to be absorbed from this air that is being cooled? What will be the resultant theatre conditions?

Heat to be absorbed in the theatre by the delivered air is 10,000 B.t.u. per min. with a full house (5 B.t.u. per min. per person). (Therefore—

$$10{,}000 \text{ B.t.u.} \times 56 \div 50{,}000 \text{ c.f.m.}$$

results in a rise in temperature to the delivered air of 11.2 deg. in absorbing the liberated heat from occupants, walls, lights, etc. It can't rise any more unless we furnish additional heat from some other source. If we don't get this other heat, what is the result in the theatre? We first cooled to 62 deg. (saturated)—that was necessary. The rise in air temperature in the room is only 11.2 deg. The theatre temperature will then be 62 plus 11.2 or 73.2 deg. What else have we? A relative humidity of 70 per cent with a wet bulb of 66 deg.

Is it not reasonable to believe that a temperature of 73.2 deg. in the house, when outside is at a maximum of, say, 95 deg. is too low to be comfortable? Most of us would probably say the temperature would be more comfortable if the house were 80 deg. An additional 6.8 deg. rise in temperature, with the same dewpoint, would reduce the relative humidity to the 55 per cent that we previously specified as desirable. The wet bulb with 80 deg. dry bulb and the same 62 deg. dewpoint would be 68 deg., or only 2 deg. higher than at 73.2 deg. room dry bulb temperature.

Now, what about the refrigeration required?

50,000 c.f.m. ÷ 13.4 = 3735 lb. air per min.

Total heat at 78 deg. ..... 40.5
Total heat at 62 deg. ..... 27.3

13.2 B.t.u. per lb.

13.2 B.t.u. × 3735 = 49,250 B.t.u.
Pump 15 hp. × 42.5 = 637

Total 49,887 B.t.u.

To cool 50,000 c.f.m. from a maximum outside condition of 78 deg. wet bulb to 62 deg. saturated, would require 250 T. of refrigeration.

Some of us will say that this is too much refrigeration for this 2000 seat house. The fact remains, however, that if you have to cool 50,000 c.f.m. from maximum outside conditions to 62 deg., you can't get away

from using 249.5 T. If you use less refrigeration, you simply don't cool 50,000 c.f.m. to 62 deg. under extreme maximum outside conditions, unless you wanted to use a heat interchanger, which is not the most practical thing for theatre work, and if you do not cool to at least 62 deg. the air will contain more moisture and will result in a higher relative humidity and higher wet bulb temperature than we are considering.

How can we avoid this high refrigeration load as well as the heating necessary at the same time and still be able to say that the theatre temperature will not exceed 80 deg. on the hottest day of the summer, and the relative humidity and wet bulb will not exceed 55 per cent and 68 deg. respectively, regardless of outside maximum conditions.

It is nothing short of wasteful to spend money and equipment and power for its operation, to cool air and condense moisture from large volumes of air, and then, exhausting it immediately to outdoors. Why not recirculate a portion of it at least? This procedure, I cannot believe, promotes the hazardous condition, resulting in all sorts of ailments and sicknesses to mankind, that some few in the past have tried to make us believe, but I do know that it does promote economy in plant equipment, size and operation, and gives the desired temperature and humidity conditions as well as air movement in the theatre for comfort.

Considering the same theatre temperature and humidity desired as heretofore, let us see what happens if we use a total fan capacity of 60,000 c.f.m., dehumidifying and cooling 40 per cent and recirculating 60 per cent. Since we are now recirculating some air, we must cool the outside air taken in, to a lower dewpoint or saturated temperature to compensate for moisture given off by the theatre occupants. Calculations indicate we must cool to 57 deg. This cooled air, mixed with recirculated air at 80 deg gives us a temperature of mixture of 70.65 deg. This then would be the delivery temperature to theatre. In taking up the heat given off by theatre occupants, lights, walls, etc., this 60,000 c.f.m. of air delivered will rise 9.35 deg., giving 80 deg. as the final breathing zone, exhaust or recirculated air temperature.

Refrigeration required to maintain the theatre temperatures would not exceed 150 T. with this arrangement. A comparison of figures shows:

This represents a saving of 100 T. of refrigeration. Assuming for a moment the power consumption of 1 hp. per ton of refrigeration, in each case, it also represents a total of 100 hp. saved. Assuming 2 gal. of water required per ton of work done for condensing purposes, would indicate a saving of 200 gal. of condensing water in favor of a system embodying recirculation. Allowing the same temperature water rise in the spray cooling system, in either case, indicates a saving in the quantity of spray water necessary, in favor of the recirculating system of over 240 gal. of water. Since this water is recirculated the saving by the reduced quantity of water necessary, amounts to about 10 hp. in the motor for the pump. Is not the 100 T. reduction in refrigeration size, 100 hp. reduced operating cost, 200 gal. per min. of condensing water and the 10-hp. reduction in pump motor size well worth considering?

I am inclined to believe that I would advocate the downward method of air delivery whenever conditions permit. Often, the owners and the architects have already proceeded with the mushroom method of air delivery in mind, and the architects' layout is too far along to permit changing this method. Then the same recirculation idea could be followed out with the mushroom method of air delivery as with the downward method. In compromising (and engineering is full of that) this will give you some idea of the disadvantages set forth above, but will also embody some of the advantages considered possible by the downward method, due to the recirculation of air.

Mr. Blanding's proposal was to zone the theatre and use only such ventilating equipment as would be required by the number of patrons actually in the house instead of running the equipment at full capacity all the time without regard to the actual number of people present.

In considering the subject for the ventilation and heating of the moderate size neighborhood theatre, careful consideration must be given to the fact that the theatre is only partially occupied over a large percentage of the period through which it is operated, and that the ideal system of heating and ventilation is one in which not only the volume of air for ventilation, but the temperature of the house in parts occupied can be easily and quickly as well as accurately controlled.

Normally, the average moving picture house fills from the center of the house backward and to the side, filling the forward parts and extreme side seats last. The house is but partially occupied many hours of its operation, from one-third to one-half of its capacity, and this means that really only the center zone toward the back of the main floor and the front five or seven rows in the balcony are occupied. The plan submitted was developed with the idea of zoning the theatre so that the temperature of air could be controlled in certain parts of the house independent of others and that the volume of air or the admission of air to certain parts of the house could be controlled from a central point.

We have also given consideration to the summer condition and application of refrigeration as well as to the winter condition where heating is necessary. The system is so arranged that for winter operation, a tempering heater, re-tempering heater and reheater coils are installed so that the air may be sent into the house through double mixing dampers either at 65 deg. or as warm as is necessary to heat the house. In summer the arrangement is such that part of the air can be passed through the air washer system and cooled and another part of the air recirculated at the warmer temperature to reduce the relative humidity, the great feature being that the thermostat which controls each zone in winter, also functions during the summer to maintain comfortable temperatures. The volume of air which is recirculated is also controlled by the operation of the dampers.

In the accompanying sketch the method in which the house was zoned is shown. Each zone is furnished with a positive cut off damper for volume and a mixing damper for temperature, switches being provided so that the ventilation in any part of the house may be controlled. The fan should be provided in this instance with a variable speed motor and indicating pressure gage on the plenum side should be placed at the fan controller so that a constant pressure could be maintained on the plenum chamber regardless of the number of openings into the theatre which are opened or closed.

The plan has upward ventilation using a design of mushroom which blows longitudinally with the seats instead of around a mushroom head.

Dr. Hill concluded the discussion by describing a pulsating system for creating momentary drafts. While we all know that prolonged exposure in a draft, that is, even for 2 or 3 min. at a time, subjects one to colds and other such diseases of the respiratory system, we also know that momentary exposure in a draft for a period of a few seconds is highly beneficial to our physical comfort when we are overwarm or in a close atmosphere. Consider how refreshing it is to sit in front of an oscillating fan on a warm day, where we get an occasional draft that lasts for a few seconds at a time. Dr. Hill's idea is to provide for such a draft in the theatre.

This provision calls for a system of wall ventilators located somewhat above the breathing zone that would, by means of suitably arranged louvers, direct the properly conditioned air out and toward the rear of the house. Ordinarily these registers pass sufficient air to meet the usual requirements but are so provided with dampers that for a period of say 10 or 15 sec. out of every minute they may be opened wide and allow an extra quantity of air to pass through at a high velocity, in the neighborhood of 1000 ft. per min. The dampers on the various registers are so interconnected that they open successively beginning at the front of the house and passing to the rear.

Interconnection is such that, by means of a motor or compressed air operated device, the first register may be opened wide for, say, 15 sec.; it then closes down to the normal opening and at the same time the second register opens wide and so on back. The result is a succession of waves of high velocity air passing back over the breathing zone. Exhaust openings are arranged at the rear of the theatre through which the air is discharged to atmosphere or partially recirculated as desired.

# Economics of Refrigerating Plants

ENGINEER SHOULD HAVE A KNOWLEDGE OF THE BUSINESS SIDE AND MANAGER SHOULD APPRECIATE VALUE OF ENGINEERING WORK. BY VICTOR J. AZBE*

PRIMARILY the intention of an ice plant owner is not to make ice, but to create a profitable return on the money invested. This fundamental purpose often is forgotten when expenditures are made and also many times when they should be made. As a result, the balance sheet of many refrigerating plants suffers, because money was invested thoughtlessly or because it was not invested. It is safe to say that if the right thing would be done at the right time, very few plants would ever have to use red ink to enter sums into the loss columns of their ledgers at the end of the year.

If a plant loses money, it is always possible to trace the cause to lack of business forethought or lack of engineering ability. Poor engineering ability is especially harmful to an ice plant, but good engineering can easily be offset by poor business policies.

It generally is assumed that the engineer will furnish engineering ability, and the plant manager business ability, and with this combination the plant will be fairly well off if the manager and engineer have confidence in each other and co-operate. A still more satisfying condition, however, would be for the engineer to have engineering ability plus a certain amount of knowledge of business fundamentals, and the manager to have business ability plus a certain amount of engineering knowledge. With such a combination, the owners of the property would be fortunate, the investment safe, and the plant a money-making success.

## ENGINEER IS AN IMPORTANT FACTOR

THERE IS hardly a business where the engineer is of so great importance as in the refrigerating plant. The engineer can either make or break the plant and many a one is broken or at the point of breaking. The reason for this is that there is so much engineering in connection with a refrigerating plant, so much applied physics which the engineer has to be conversant with, that otherwise he cannot be expected to know what is going on. The mere matter of keeping the machinery going is the easiest part of it and one who knows how to run the plant is far from being a successful operator from the money making standpoint. The plant may, of course, be making money; but that may be more in spite of the engineer than on account of him. If he were a better grade engineer—that is, a real and not a makeshift engineer—the plant would be making more money and probably would be able to make ice cheaper as well.

While the engineer can be tremendously handicapped by the management, that part will not be discussed here, since this paper is intended primarily for the engineer. It is hoped that complete co-operation will exist between engineer and manager because it is so extremely important.

One of the most important pre-requisites for the successful operation of a refrigerating plant is, of course, the necessary knowledge of what is going on. After the engineer becomes thoroughly posted on what is going on, then he must begin to interpret the results, and after that, plan to make improvements.

There are two classes of improvements—those which cost money for their successful accomplishment, and those which do not require capital. It is needless to say that the latter should be executed first; however, many an engineer is walking around with an ideal dream in his head that would cost thousands of dollars to execute, when at the same time conditions causing waste that could easily be corrected are going on in his plant, losing large sums of money and for the improvement of which no efforts are being made.

It is my personal policy always to oppose spending large sums of money in plants where I note that the best is not done with what is on hand. Investment under such conditions is not safe, and while a certain gambling spirit is desirable in business affairs, to give good equipment to an engineer not able to operate it is too unsafe from the investment standpoint. Tremendous amounts of money have been sunk into refrigerating plants from which no returns were ever obtained.

*Consulting Engineer. Mr. Azbe gave this address before the National Association of Practical Refrigerating Engineers at St. Louis, last November.

If an engineer operates his plant properly, after he has corrected all the faults he can without any large expenditures, then it becomes time for him to see where money investments could be made that would prove profitable from the standpoints of labor saving, fuel saving, increased capacity, and, most important, from the money-making standpoint. That an appliance will save fuel and labor and increase output is, of course, important; but will it save money? This last is the big and paramount question. If it does not save money, it is no good and should not be considered.

Some improvements, especially in the welfare line, may show that apparently they do not pay from the money-making standpoint, and if they do not, they should not be made; but often if the reasoning is carried far enough, it will be found that they will pay. Fortunately, in engineering the conclusions can be arrived at more easily; but even there many things should be taken into consideration which as a rule are overlooked. Many an engineer figures the saving in fuel and applies the entire figure towards the cost of the new apparatus, entirely ignoring interest, depreciation, maintenance, taxes, insurance and profit on investment.

### All Fixed Charges Should Be Considered

Let us assume we want to purchase a new machine of some kind which will save, say, $1000 a year in fuel and which will cost $6000. Apparently this would be a good investment, and as some would figure, the machine would pay for itself in 6 yr., but is this really the case? We must remember that to buy this machine money would have to be borrowed, or equivalent to that, and the interest may be about 5 per cent. Then the machine would depreciate, for which a 5 per cent allowance or more should be made. Then again, there will be operation and maintenance costs, repairs, etc., which may amount to another 5 per cent of the original cost per year. Insurance and taxes will amount to about 1 per cent. On top of this is the profit, which may be assumed as 9 per cent, thus making the total 25 per cent. Consequently, if the machine is to pay for itself, it should save 25 per cent of $6000 every year, or $1500. Since it saves only $1000 a year, it evidently would not pay.

If the engineer would use the above method of estimating the saving, he would have little difficulty in convincing the manager or the board of directors as to the expediency of making investments. The board out of necessity must think in these terms, and if the engineer also does it, the gulf that now exists between the two will be greatly reduced. In fact, the application of this simple fundamental principle will increase the standing of the engineer in the eyes of a financial man who does not know anything about engineering, more than anything else could. Many an engineer can greatly benefit himself thereby. As it is, the proposals for improvements made by engineers are looked upon with suspicion, because they often are not based upon business principles, and some of them are merely pipe dreams.

In some cases the above stated percentages would have to be modified, as for example, where a machine is being replaced or where there is a possibility that the life of the unit would be less than 20 yr. If the life of an improvement may be only 5 yr., the item of depreciation must be quadrupled and the total charges against it should be 40 per cent instead of 25 per cent.

Interest to be charged should be the prevailing rate of banking concerns in that territory. The profit item may not be clear to some, but the writer's contention is that there is a certain risk connected with every investment and the investor should be well paid on account of the risk. The greater the risk, the greater the profit should be, and while the risk with a whole ice plant may not be so great, the risk with an individual unit of equipment, especially with an untried machine, may be considerably greater. The profit item should be charged against every improvement excepting the improvements that come under the maintenance heading and are paid out of that fund—but even there, they should be considered.

Many refrigerating plants with great impressive buildings, and modern machinery, well operated, are financial failures, because investments were made without the 25 per cent charge having been considered. From the engineering standpoint, the plants are a huge success; from the business standpoint, a total failure. The shell makes a fine appearance while the core is rotten, eaten by the worm of the too great overhead.

While this discussion may appear pessimistic in its attitude, and have an apparent tendency to discourage monetary investments in ice plants, this is not the intention, but only to emphasize proper procedure towards the end of logical investment. There are great opportunities to improve the majority of plants. Most plants have weak factors which, if corrected by a monetary investment properly applied, will bring a return equaled only by the return of a successful oil stock, with infinitely greater safety.

We must put ourselves in the frame of mind which will permit us to realize that from the efficiency standpoint the refrigerating industry ranks very poorly. In almost all plants large sums are wasted, larger in some cases by many times than the profits shown by the books. This should not be the case and it would not be so if the engineer were a real engineer and a fairly good business man also.

### Engineer Should Analyze Operating Conditions

If his plant is losing money or making little money, the engineer should take stock of himself and of the plant, and ask himself the following questions:

Is my ammonia suction pressure low? What is the reason for this? Is it that I have too little pipe surface, or not enough brine circulation, or are my suction pipes too small? How much would it cost to correct the difficulty? How much net gain in fuel saving will the company receive from the improvement? Will the capacity be increased? If so, how much, and what will be the monetary value of this increased output?

Remember that in a really uptodate plant, back pressures as high as from 50 to 60 lb. gage are maintained for the purpose of water and ammonia liquid cooling. Back pressures in ice tanks range around 25 lb. gage when the plant is operated at peak. Such conditions are conducive to power saving and may also be conducive to money saving, but not necessarily so. The economic value of such high back pressure depends upon circumstances such as size of plant, cost of power or fuel, nature of load factor, etc., each one of which must be carefully analyzed if the engineer wishes to know

the whole story necessary in order to be an intelligent judge of what is proper.

Such reasoning should also be applied to condenser pressure and the various influences which affect it—such as weather conditions, cooling tower construction, condenser construction, cost of water pumping, size and directness of discharge lines, etc. It also should be applied to boiler rooms, engine room, auxiliaries, use of labor, etc.

Every engineer should train his mind to become analytical. The eternal "why" should control all his reasoning and actions. He should have a proper sense of balance. He should not have any pet ideas. Cold-blooded scrutiny of a proposition is all that counts. All improvements contemplated should be considered by the "investment and return" method.

They say a woman is as old as she looks. The same can be applied to an ice plant; it also is as old as it looks and many of them certainly do look old. The importance of a clean, well-kept refrigerating plant from an economic standpoint, cannot be exaggerated or over-estimated. I have visited many plants where I found that cleanliness of premises and of machinery, and economical operation, traveled hand in hand. The ice plant should be the community's pride and not its necessity.

Most plants use too much fuel, too much labor, too much ammonia—and make too little ice and they generally present a very unsanitary appearance. Let us apply the reasoning suggested and correct these conditions.

## Developing Clear Thinking

CLEAR THINKING depends upon well-established mental habits of simplicity, definiteness, and sincerity of purpose. These three habits, says the Business Consultation Bureau of La Salle Extension University, form a valuable barrier against the common faults of vague and indiscriminate thinking. Examine carefully your habits of thought. Subject yourself to rigid self-examination. Your brain is subject to the law of habit; what it is made to do often, it comes to do automatically. Habit is formed by frequent repetition. Take strict account of your habits of thought and correct or eliminate undesirable features.

There are seven rules of clear thinking:

1. Secure definite ideas. This demands mental alertness and avoidance of vagrant thinking. To get clear concepts of things, your mind must be kept "on the job" all of the time.

2. Accept as true only that which you know to be true.

3. In studying a subject begin with simple ideas and gradually advance to more complex. Plunging in the middle of a subject is perhaps one of the most prolific causes of incorrect conclusions.

4. Divide the subject for study into several parts. Consider each part separately.

5. Define words and terms which are in the least degree obscure and equivocal. It will surprise you the number of words that are used carelessly and indiscriminately. Many words have more than one meaning.

6. In considering a subject include all the information necessary for a clear understanding. Do not start with a preconceived idea and try to find information to substantiate the idea. If the original idea is wrong you may be able to prove it right, if your mind is closed to any but a special kind of information. Keep your mind open and study all sides of the subject.

7. Aim for thoroughness in everything you undertake to study. This is a common fault—we all want to do things too quickly. A short-cut to wisdom often defeats the end in view.

## A Steaming Melody

By R. G. SPOONER

WHY don't we sing a song of steam,
As other songs we sing,
And let the echo of our strain
To every country ring?

There's music in the motor
As it swiftly purrs along.
Why can't that humming melody
Be transposed into song?

The clanking of the crosshead,
As it travels through the guides
Tries to catch the thumping crankpin,
With its long and sweeping strides.

And the popping of the "Safety"
With a sudden muffled roar
Tells us that it's blowing music
To a song and nothing more.

With the non-condensing engine
There's a chug at each release
At each choke it tries to tell us
Where there's music there is peace!

Seems to make the burden lighter
And your soul will change within
When the valve-latch starts its chatter
And you hear the turbine sing.

From the steam chimes of the whistle
Sounds the music of a bell,
As its strains vibrate the ether
Telling all there is to tell.

In the steam that's superheated
There's a note in each degree
As it travels through the pipe lines
Singing songs to you and me.

Now I've grasped that inspiration,
And I know it's not a dream;
There is music in our calling,
For I've sensed the song in steam.

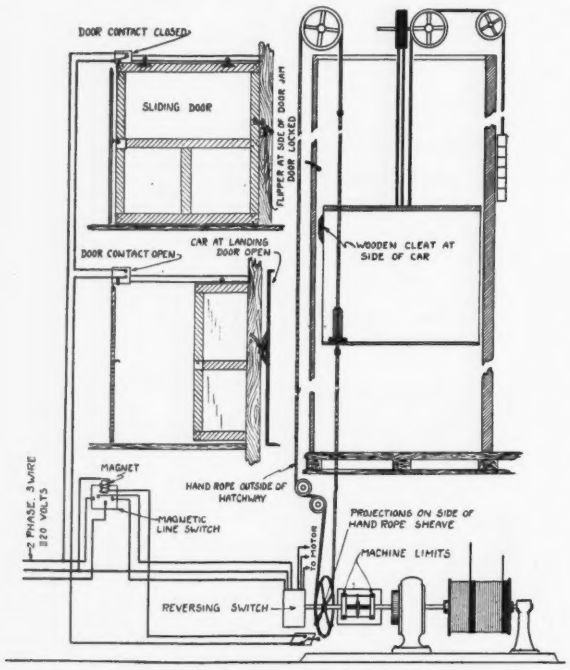
## Correction

IN CONNECTION with the article on the Kansas City Cold Storage & Warehouse Co. plant, in the Feb. 15 issue, credit to S. Scott Joy, architect of Chicago, was omitted.

# LETTERS DIRECT FROM THE PLANT

## Elevator Control

WE HAVE a passenger elevator, run by the tenants, that has given us a lot of trouble. The rotor of the motor had the end rings soldered and the solder was melted off several times, also the brake magnet burned out by trying to run the machine on single phase, caused either by a fuse blowing, or by poor contacts on switch, when the hand rope was not pulled over far enough and left in that position until the motor started to heat up.


DOOR CONTACT CLOSED
SLIDING DOOR
FLIPPER AT SIDE OF DOOR JAM DOOR LOCKED
CAR AT LANDING DOOR OPEN
DOOR CONTACT OPEN
WOODEN CLEAT AT SIDE OF CAR
MAGNET
HAND ROPE OUTSIDE OF HATCHWAY
MAGNETIC LINE SWITCH
PROJECTIONS ON SIDE OF HAND ROPE SHEAVE
MACHINE LIMITS
REVERSING SWITCH
2 PHASE 3 WIRE 220 VOLTS

METHOD OF EFFECTING SAFE ELEVATOR CONTROL

The smell of the burning insulation going up the hatch would cause someone to cry "fire!" but too late to save the rotor or the brake. The doors at the landings were of the swinging type and would be blocked open. It was finally decided to make a change in the outfit with the least possible cost.

The end rings of the rotor were welded, by putting the rotor in water, up to within an inch of the rotor bar. This kept the rotor bars from getting too hot and burning the insulation between them. After the welding, the rotor was trued up and balanced in the lathe. The doors at the landings were made to slide instead of swing, with an electric contact at each door, and a magnetic line switch cut in on the main line to the motor. Section A shows how the hand rope was put outside the elevator hatchway, so that the elevator could be brought to the desired floor. Section B shows a flipper attached to the door casing, and engages in a hole in the panel of the door which prevents the door from being opened after the car leaves the landing. Section C shows a wooden cleat at the side of the car lifting off the flipper, so that the door can be opened. Opening the door breaks the connections at the door contact so the car can not move while the door is open. Section P shows the magnetic line switch in series with the main current to the motor, the magnet of which is connected in series with the door contact. When the hand rope is pulled over far enough to make good contact at the reversing switch, the projections on the side of the hand rope sheave closes the last contact, completing the circuit through the magnet which closed the line switch admitting current to the motor and brake. It has given no trouble in the past 2 yr., has paid good interest on the money invested, and saved the engineer many worries.

Springfield, Mass. THOMAS SHEEHAN.

## Steam Boiler Cleaning

How TO keep the inside of a boiler clean is always a live question to the engineer in the plant not equipped with a water softening apparatus, evaporator, or other feed water purifying outfit. After a number of years service in small power plants of from 300 to 600 boiler horsepower, I am convinced that the automatic boiler water skimmer is one of the best helps towards keeping a boiler clean. The complete skimmer, including the scum collecting tank, is not expensive and is not difficult to install, although a complete outfit is necessary for each boiler.

Although many such skimmers are in use, there are firemen using them who do not understand how the work is done. When water enters a boiler, the high temperature and the circulation cause much of the foreign matter in the new water to rise to the surface in the form of a scum. The circulation of the water keeps this scum moving for some time until its density is increased by amalgamation, when it sinks and settles on the tubes and plates where it is converted into scale by the high temperature.

To remove the scum before it sinks and store it in a reservoir from which it can be blown out with a wastage of but a small quantity of water is the function of the skimmer. The claim has been made that such skimmers will actually remove scale already formed in a boiler, but my own experience formed from observation and experiment with different skimmers is that they will not do so although they prevent the formation of new scale when properly installed and frequently blown out. In one plant where I worked 5 yr., there were three return tubular boilers, two of which were equipped with skimmers. Water treating compound was used in the three boilers and the skimmer tanks were blown out

every few hours. The boilers equipped with skimmers had from 60 to 75 lb. of scale removed at cleaning each month; the skimmerless boiler gave up from 150 to 200 lb. during the same time. A skimmer was connected to this boiler and the scale accumulation dropped to about the same amount as that which collected in the other boilers. Considerable scale had formed in a boiler in another plant. When I started to work there, I recommended the installation of a skimmer and it was put in. The agent persuaded the owner that it was needless to use compound and that a clean-out once every three or four months was all that was necessary as the skimmer, so he claimed, would remove the scale already formed and prevent the formation of new scale if the scum collector was blown out every 3 hr. or less, while the boiler was in service. I did not agree with him, but the plant owner insisted that the plan be carried out, probably the idea of saving the cost of the compound and the cost of the cleaning time was the reason for his insistence. There was considerable scale forming material in the boiler feed water and although the skimmer was blown out every 3 hr., so far as I know, at the end of 3 mo., when the boiler was opened for cleaning, not only was the old scale not removed, but the scale was thicker than it had been in the first place.

My own opinion is that if the skimmer had not been faithfully blown out, so much scale would have collected during the three months that the least damage that would have occurred would have been a boiler made unfit for anything but scrap. An agent handling a good boiler room appliance will soon destroy faith in its value when he misrepresents its ability to do certain things for the sake of making a sale. An owner is sometimes willing to be persuaded along certain lines when he sees an apparent gain ahead, and a great many engineers have not the gift of speech, such as a convincing salesman may possess, to make him see the light. When no external water purifying apparatus is available, an automatic skimmer combined with a good compound and frequent careful boiler cleaning, is the next best safeguard of steam boiler safety.

Toronto, Canada. JAMES E. NOBLE.

## Tempered Coal in Underfeed Stokers

I READ with much interest Mr. Marsh's remarks in an article of the Feb. 15 issue in regard to tempered coal, and also Mr. Fisher's article of the March 15 issue, and would say that I agree with Mr. Fisher. I have had an unpleasant experience with wet coal this winter on account of considerable snow being mixed with it, and I find that it is a decided detriment to the successful operation of underfeed stokers.

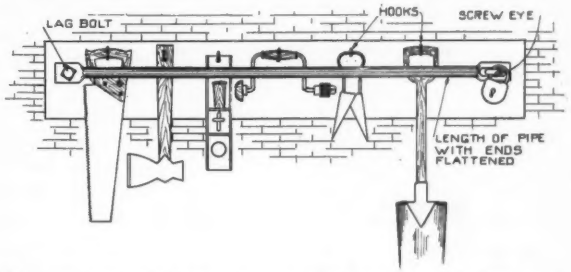
In the first place, the wet coal will not feed down in the hoppers; it taken two men two-thirds of the time poking it down in front of the rams. It packs into a hard mass in the mouth of the retort, which makes it necessary to run the stokers faster in order to keep up the fire, and then instead of feeding down by the agitation of the grate bars, it piles up in the center of the furnace and does not open up as it should for proper combustion. In order to get the desired results, the fireman has to loosen it up with a bar.

Under these unfavorable conditions, the boiler efficiency is cut down from 3 to 5 per cent. All of this I consider a great detriment to the successful combustion of wet coal in underfeed stokers, and I am sure when we get in a supply of dry coal, the fireman will not temper it with water.

Southington, Conn. GEO. A. HUBBARD.

## Simple Lock to Curb Tool Borrowers

PROMISCUOUS BORROWING of tools can be prevented by means of a simple bar lock, such as illustrated in the accompanying sketch. This is an attachment which




LOCKING ARRANGEMENT APPLICABLE TO AN EXPOSED TOOL RACK

lends itself to exposed tool racks or tools hung in a row upon hooks. The bar can be made up of either wood or iron, while a section of pipe affords a simple and readily made part. The arrangement consists in securing the bar at one end with a lag screw or heavy wood screw, at a point about 2 in. below the hooks.

In order to pass over the head of an eye bolt, the opposite end is opened and the fastening is made secure with a padlock. This construction is adaptable to woodworking tools, machinist tools, plumbing tools, or for shovels, saws, wrenches, furnace equipment, scrapers, etc., such as are too large to be accommodated in the usual tool box. G. A. LUERS.

Washington, D. C.

## Device for Opening Flue Doors

WHEN IT is necessary for any reason to open the flue doors on our horizontal return tubular boilers, it is necessary to use a step ladder to open the upper latches. As this is a dangerous practice as well as inconvenient, I devised an extension handle that could be used with greater convenience.

Through the handle of the upper latch I drilled and tapped a small hole into which was screwed an eye bolt. An iron rod about as long as the door is high was forged with an eye on one end and a handle on the other. This eye was fitted into the eye bolt on the latch. Now by simply pulling the rod to one side and then pushing up, the latch is easily unhooked and the door may be opened from the floor.

Seymour, Conn. CHARLES MEHR.

ACCORDING TO the Bureau of Railway Economics, the coal consumed by the railroads in 1922 was 128,000,000 net tons, compared with 122,000,000 in 1921. These figures show an increase of about 5 per cent in the consumption of coal.

As the increase in freight business in 1922, in terms of net ton miles, was about 9 per cent, the figures for 1922 reflect the increased efficiency in fuel consumption accomplished last year.—Railroad Data, March 22.

## One-Pipe Hot Water Circulating System

In the accompanying illustrations are shown the patent drawing of a one-pipe hot water circulating system which has been installed and given satisfactory results for over a year.

As may be noted, it consists essentially of a heater in the basement connected to a closed system of piping

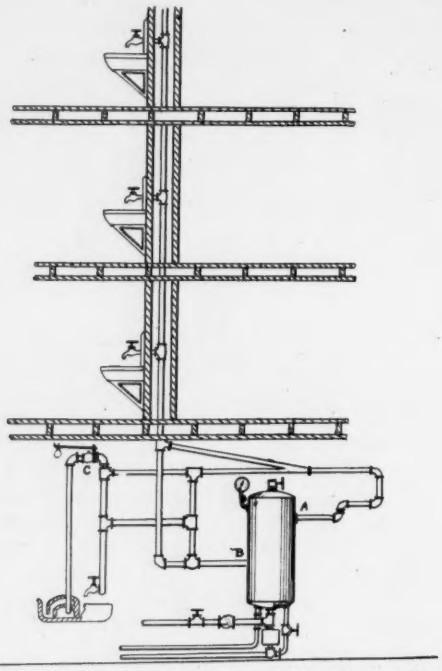


FIG. 1. DIAGRAM OF ONE-PIPE HOT WATER SYSTEM

also in the basement, feeding one or more vertical risers to which a number of faucets are fitted. This single vertical riser or lead pipe has all the practical advantages of a two-pipe system.

In this system any suitable type of water heater connected to the main source of supply is provided with a

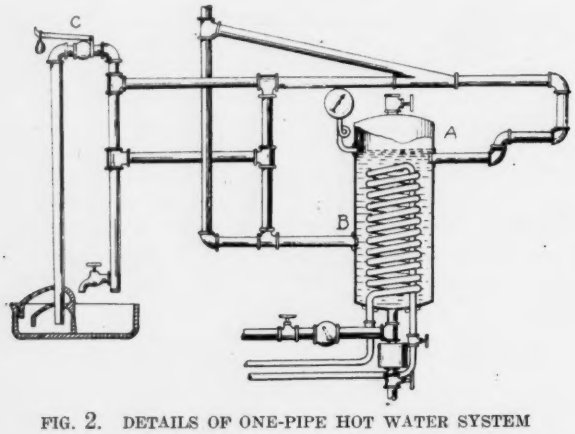



FIG. 2. DETAILS OF ONE-PIPE HOT WATER SYSTEM

means for automatically admitting water into the system until a certain predetermined pressure is reached. The heater is provided with an outlet A near the top, whereby hot water will be taken from the boiler, and this outlet is connected to the lower part of the vertical pipe or other supply pipe delivering heated water to the different floors of the building. The cold water returns through the same pipe to a point near the heater, where it enters a return branch pipe connected to the lower part of the heater as at B.

To prevent the pressure in the system from rising above a certain safe limit, a relief valve is provided at C, the discharge of which connects into a series of baffle plates to muffle the sound caused by the discharge of water and steam.

New York, N. Y. P. J. Molloy.

## Advantages of Small Steam Pipe Lines

There is such a thing as making steam pipe lines too large in spite of the advantages of accompanying low steam velocity and slight pressure loss. The trick is to select pipes of the *right* size—neither too large nor too small.

The size of a steam pipe is usually based on steam velocity. For saturated steam, 6000 to 8000 ft. per min. is common practice, while for superheated steam 8000 to 12,000 ft. is often used. Before going above 8000 ft. per min., however, one should be certain that the piping and valves are of sufficient size and that the design is such that the pressure drop will not be excessive, so that there will be no wiredrawing through valves, and no loud whistling noises. By exercising judgment, velocities can sometimes be brought up to 14,000 ft. per min. for large reciprocating engines or steam turbines. Velocities are sometimes actually brought up to 21,000 ft. per min.

Advantages of small piping are:

1. Lower first cost. The pipe weighs less per foot. Thinner pipe can be used to withstand the same pressure, consequently the initial investment is less.

2. Correspondingly smaller and less expensive fittings.

3. Less surface is exposed, hence the radiation losses are lower.

4. Less insulation is required because of the small surface.

5. Greater friction loss through the small pipe tends to superheat the steam. As a result, the steam may reach the engine or turbine, after a long run, in a perfectly dry state. The pressure loss is thus converted into useful heat energy.

It has been suggested by an engineer, and the suggestion seems to have some merit, that in long straight runs of steam pipe large valves be used, with smaller intermediate pipe. In this way, the steam velocity through the valves would be lower, or "just right," and through the smooth pipe the velocity would be high, or, again, "just right." If any of the readers have had experience with pipe lines designed in this way, the writer would like to know whether or not they have been successful.

Newark, N. J. W. F. Schaphorst.

## Babbiting a Valve Disc

Recently there was an article in Power Plant Engineering describing a method of reseating a globe valve disc, which recalls to mind the method we used on a 5-in. I.B. globe valve on a 125-lb. wet steam line. The face of the disc on this valve was made of hard rubber or fiber and part of this had fallen out. We took

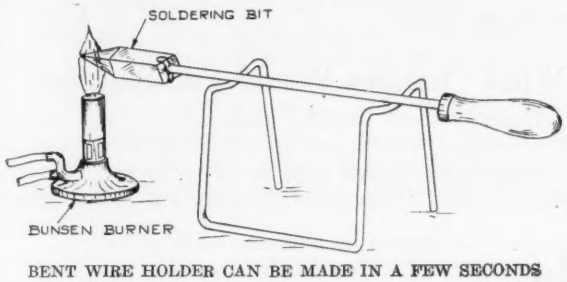
the valve disc out, removed the remaining rubber and poured in its place some babbit, taking care to run the groove brimming full. Then, with a file, we smoothed the babbit down level with the rest of the disc and re-replaced the disc in the globe. This was 2 yr. ago and since then we have had no further trouble with this valve.

Fredericksburg, Va. J. B. FICKLEN.

## Holding the Soldering Bit Over the Bunsen Burner

FOR HEATING the soldering bit on the work bench the bunsen burner affords a clean and convenient means, the only requirement being some means of supporting the bit over the flame. The sketch illustrates about the simplest holder for the bit which could be desired.

One piece of wire, with six bends, in the shape shown, is the total sum of work involved to make this holder. It is hardly necessary to make up a permanent fixture




BENT WIRE HOLDER CAN BE MADE IN A FEW SECONDS

for this purpose, when this fixture can be memorized and made up in a fraction of a minute when required. Any piece of wire and a pair of pliers are all that is required.

G. L.

## Where Forethought Was Needed

HAVING a 2½-in. blowoff valve of the Y-type that started to leak badly the engineer requested a new valve of the same type and make that was in use. This was bought by the plant owner and placed at the next boiler cleaning.

In examining the valve later on, it was found that this valve was of a type which had a removable seat and disc. All that would have been necessary in the first place was to get a new seat and disc to replace the old one without removing the valve from the blowoff pipe, with much less work for the engineer and much less expense to the plant owner.

In this instance the price of the new valve was about $35 to $40. The time required by the engineer and helper in removing the old valve from its connections added considerably to the expense, perhaps also new nipples and other fittings were required to make the joints meet again when the new valve was placed. Had the engineer examined the old valve thoroughly before ordering the new valve, he would have saved quite a sum of money for the plant.

To avoid unnecessary expense and labor, the engineer of a power plant, no matter how small, should examine closely each part of the equipment no matter how small or unimportant a certain apparatus may seem to be. It pays in the long run.

Should there be no other way of getting such information regarding apparatus that may be in service, write to the maker of the apparatus, who will gladly give this advice or any other information that may be desired.

In the plant of a manufacturing concern, a water filter was installed and to get this filter sufficiently out of the way it was decided to locate it in one corner of the building back of a number of machines. There was nothing wrong in placing the filter out of the way as much as possible, but in doing this it was necessary first to move a number of machines to get it in place; then after the filter was in place, the machines had to be moved into place again.

Whenever it was necessary to clean the filter, which is done every 5 or 6 mo., a manhole plate has to be removed so as to get the gravel out of the filter. To get at this plate, it is necessary first to remove all the machines that are located in front of the filter; this work alone takes from 5 to 6 hr. at each cleaning, besides the time required to clean the filter.

All this waste of time was due to the fact that someone in the plant used poor judgment when installing the filter. In this instance there was nothing to prevent locating the filter in a more convenient part of the building.

When installing apparatus, there are many points that must be taken into consideration before deciding on the location, such as the labor and expense required in installing the apparatus, that there may be nothing that is liable later on to cause unnecessary labor and expense in keeping the apparatus in working condition and repair.

H. A. JAHNKE.

## Some Causes of Pounding

EXPERIENCE HAS taught me that the common "click" in an engine cylinder is often caused by a ring being too loose, it can usually be cured by peening the inside of the ring, unless it is very loose. These clicks are sometimes difficult to locate. I have located a persistent click as being caused in the valve chest by the valve being warped and this striking the port edges. This click can be cured by scraping the seat and valve.

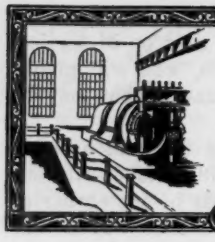
Improperly fitting rings in a cylinder will cause a pound in an engine by allowing loss of compression, and an improperly set valve may cause a pound. I have heard a pound in an engine that was caused by the piston being too tight at one end of the stroke. Too much compression in a balanced valve engine will lift and slam the valve.

Pounding may also be caused by the piston traveling part way over the port and on to the valve opening; the steam will make the piston hammer on the opposite side of the cylinder.

I have tried to mention causes of clicks and pounds in engines here which have not before been discussed in the correspondence section. Of course there are many other possible causes of these undesirable noises, but the foregoing ideas may help some readers to a solution of a difficulty.

Toronto, Ont JOHN THORNE.

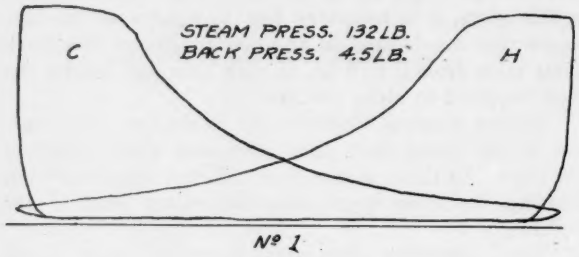
SUCCESS seldom stays with those who gloat over the failure of others.



# PROBLEMS IN OPERATING POWER EQUIPMENT

## What Causes the Pound?

I WOULD like to have comments from readers of Power Plant Engineering on the accompanying indicator cards, from an 18 by 42-in. Corliss engine running at 80 r.p.m. What causes a knock in the engine when the




INDICATOR CARDS TAKEN FROM AN 18 BY 42 IN. CORLISS ENGINE

valves are set to give Card No. 1? When the valve setting is changed to give Card No. 2 with heavy compression and late release, it runs as quietly as can be. With the first setting, the pounding takes place just as the engine takes steam on the head end and it seems to be in the cross head. It makes no noise on the crank end; but if I add compression only on the head end, it will pound just the same. I have to have compression on both ends to make it run quietly.

I have gone all over this engine and the only thing that I can see that might account for the pound is 1/16 in. wear between cylinder and piston. I have, however, run engines with this much lost motion and they did not make much noise. C. M. S.

## What Causes the High Steam Consumption?

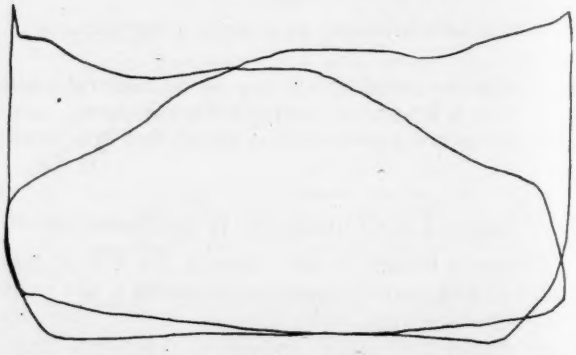
WHAT WOULD cause a 600-kw. steam turbine running non-condensing to show 15 or 20 lb. more steam consumption per kw.-hr. than the manufacturer's guarantee? Would a dirty steam separator that had not been cleaned for quite a while cut down the efficiency of the turbine? M. P.

## Relative Life of Steel and Wood Water Tanks

WE HAVE two 1200-bbl. wood water tanks containing water for sprays and jacket water for gas engines. We will have to replace one of the tanks soon with either a steel or wooden tank between which there is little difference in cost. What are the lasting qualities of a steel tank compared with those of a wood tank? The tank is 25 ft. 9 in. by 16 ft. 2 in., 1500 bbl. (42 gal.) and is made of copper bearing steel; sides and bottom are 12 gage plates. C. A. M.

## What Changes Would You Suggest?

WHAT CHANGES should I make on the valve setting of my engine to get a better card? The accompanying card was taken from a 13⅝ by 32 by 24-in. cross compound engine. The initial pressure was 155 lb. gage;



INDICATOR CARD FROM LOW PRESSURE CYLINDER OF CROSS-COMPOUND ENGINE

the receiver pressure, 17 lb. gage, and the vacuum, 25 in. of mercury. The normal speed is 111 r.p.m. I can not account for the peculiar waves in the steam line nor the gradual drop in the back pressure to the point where compression begins. I would appreciate having the opinions of your readers on these questions.

J. M. B.

## Piston Ring Sizes

IN THE Mar. 1 issue of Power Plant Engineering, I. W. C. wishes to know how to determine the sizes and thickness of piston rings. He says that the engine builders sent him a ring that was too large for the cylinder and that they told him to cut the ring and peen it to fit. It seems to me that if the ring is too large to fit the cylinder, it would be a poor policy to cut it, and draw it to the proper circle by peening it, as one would have to be skilled to do a perfect job, and not draw it

in too much and not lose the tension on the cylinder wall.

I would prefer making a ring the same size as the cylinder bore, and peen it before it is cut; this will stretch the inner surface of the ring so that when it is cut it will spring open; when compressed and placed in the cylinder it would have a good tension on the cylinder wall. In either case, the ring after peening should be placed in a lathe and the sides faced off, so it would fit the groove in the piston head properly. I doubt if there is any man who can peen a ring and have it exactly round when he gets through.

I have never been able to find a formula governing the sizes of piston rings, but here is one I derived; perhaps it will be of some use to I. C. W. and other readers who are confronted with similar problems. I have used this formula for a number of years. For every foot diameter of the cylinder, the outside diameter of the ring is ¼ in. larger than the cylinder diameter.

The amount to be cut from ring to make it fit the cylinder is equal to 3.1416 times the difference in diameter between the ring and the cylinder.

Example: What is the diameter of the ring for a 24-in. cylinder and how much should be cut out?

$$\text{Diam.} = 24 + 2 \times \tfrac{1}{4} = 24\tfrac{1}{2} \text{ in.}$$

$$\text{cut out} = 3.1416 \times \tfrac{1}{2} = 1.57 = 1\text{-}9/16 \text{ in.}$$

To determine the thickness of an eccentric ring, use the following formula, where W = width of ring in inches. For rings not over 12 in. diameter and 1 in. wide,

$2/5 \times W$ = thickness on thin side;
$3/5 \times W$ = thickness on thick side.

For rings of 12 in., and not over 18 in. diameter and 1⅛ in. wide,

$(2/5 \times W) + 1/16$ in. = thin side;
$(3/5 \times W) + 1/16$ in. = thick side.

For rings 18 to 24 in. in diameter and not over 1¼ in. wide,

$(2/5 \times W) + \tfrac{1}{8}$ in. = thin side;
$(3/5 \times W) + \tfrac{1}{8}$ in. = thick side.

Example: What would be the thickness of the thick and thin sides of an eccentric piston ring having a diameter of 24 in. and a width of 1¼ in.? Substituting for W, we get:

$(2/5 \times 1.250) + \tfrac{1}{8}$ in. = 0.625,
or ⅝ in. thick on thin side:
$(3/5 \times 1.250) + \tfrac{1}{8}$ in. = 0.875,
or ⅞ in. thick on heavy side.

If rings to be used are wider in relation to the diameter than the figures given in this formula, they should be figured as not being any wider than the maximum widths given. This will keep the rings from becoming too stiff for a given diameter. For concentric rings and those having springs underneath to hold them against the cylinder, use the formula for the thick side of the eccentric ring. Piston heads may be found where the grooves are not deep enough to take the above-mentioned rings. If so, they should be machined 1/32 in. deeper than the thickest part of the ring.

Coeur d'Alene, Idaho. L. E. HAYBARKER.

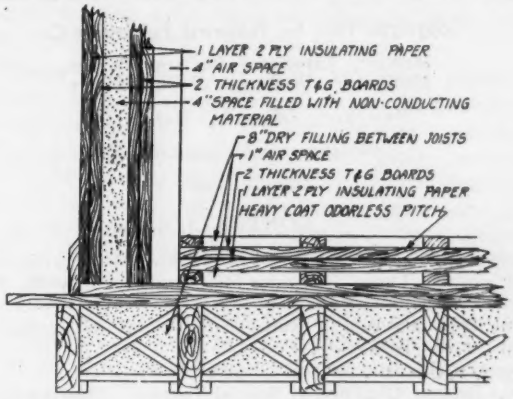
## Design of 10-T. Ice Freezing Tank

I AM CONTEMPLATING the installation of a 10-T. ice tank and would like to have your idea of what the general design should be like. What should be the dimensions of the tank? How much pipe surface should it contain? What insulation is necessary. C. D.

A. There is, of course, some latitude in the design of ice making plants, and as local conditions will necessarily govern the details of design it is impossible to lay down any definite specifications without making a lot of arbitrary assumptions.

Suppose that 300 lb. cans are used and that brine temperature is to be 14 deg. F., then the time required for freezing will be approximately 48 hr. and there will have to be twice as many cans as there are blocks pulled per day. The number of blocks pulled per day is $10 \times 2000 \div 300 = 66$ (about), so that there will be required approximately 132 cans.

Unless the space available for the tank makes some particular ratio of length to width advisable, the tank


1 LAYER 2 PLY INSULATING PAPER
4" AIR SPACE
2 THICKNESS T&G BOARDS
4" SPACE FILLED WITH NON-CONDUCTING MATERIAL
8" DRY FILLING BETWEEN JOISTS
1" AIR SPACE
2 THICKNESS T&G BOARDS
1 LAYER 2 PLY INSULATING PAPER
HEAVY COAT ODORLESS PITCH

STEEL ICE FREEZING TANK CONSTRUCTION

should be made approximately square to reduce the radiation losses. Inasmuch as the 300 lb. can is twice as long as it is wide (the dimensions being 11 by 22 by 44 in.) there should be twice as many cans along one dimension of the tank as along the other. A tank accommodating 18 cans widthwise in one direction and 8 lengthwise in the other, giving a total of 144 cans, would fulfill the requirements and leave a few extra. If there is no demand for more than 10 T. capacity the brine temperature may be increased to, say, 15 instead of 14 deg. F. Allowing for a bulkhead at one end of the tank for brine circulation, a tank about 20 ft. wide by 21 ft. long by 4 ft. deep would accommodate this number of cans.

To supply the necessary refrigerating effect, there should be provided about 210 ft. of 2-in. pipe per ton capacity, or a total of 2100 ft. The coils should run lengthwise of the cans and between every pair, so that as there are 18 rows there should be 10 banks of coils. As there are 2100 ft. of piping to be used, each bank will contain 210 ft. The length of each coil is approximately 20 ft. minus the width of the bulkhead space of 3 ft. or about 17 ft., hence there will be $210 \div 17 = 12$ pipes high.

As to the actual construction of the tank, it may be made of either wood, steel, or concrete, probably the most common being steel. The accompanying illustration is a cross-section of a steel tank showing a construction which affords efficient insulation. The total thickness is about 12 in. Four inches of this is dead air space and another 4 in. is packed with a good insulating material.

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CONTENTS


Station Operates Automatically. Illustrated....403
Putting the Turbo Generator on the Line. By H. G. Roberts. Illustrated....408
First Installation of a Ruths Accumulator in Germany. By J. H. Blakey....410
Improved Throttle Valve. Illustrated....410
Heat Balance Obtained by Special Turbine. Illustrated...411
Oil Fuel for Steam Generation. By C. H. S. Tupholme....412
Electrical Industries and the Coal Situation. By John W. Lieb. Illustrated....414
Diesel Engines in a Portland Cement Plant. By C. M. Carman. Illustrated....417
Indicators for Engine Speeds Above 2000 R.P.M. Illustrated....421
Phasing Out Alternators and Parallel Operation. By F. C. DeWeese. Illustrated....424
Interpole vs. Non-Interpole Machines. By Philip G. Bernholz....427
Motor Applications in the Woodworking Industry. By Gordon Fox. Illustrated....428
Measuring Temperatures with Thermocouples. By Irving B. Smith. Illustrated....430
Symposium on Theatre Ventilation at Illinois Chapter of A. S. H. V. E. Meeting. Illustrated....434
Economics of Refrigerating Plants. By Victor J. Azbe....437
Developing Clear Thinking....439
A Steaming Melody. By R. G. Spooner....440
Letters Direct from the Plant: Elevator Control. Steam Boiler Cleaning. Tempered Coal in Underfeed Stokers. Simple Lock to Curb Tool Borrowers. Device for Opening Flue Doors. One-Pipe Hot Water Circulating System. Advantages of Small Steam Pipe Lines. Babbiting a Valve Disc. Holding the Soldering Bit Over the Bunsen Burner. Where Forethought Was Needed. Some Causes of Pounding. Illustrated....440
Problems in Operating Power Equipment. Illustrated....444
Editorial: Development of Small Water Power with Automatic Equipment. Special Turbine Makes Heat Balance Possible. High Speed Indicator Development. Oil Engines Require Intelligent Care....446
Off Duty....447
Possibilities of Water Power for New York City. Illustrated....448
Multiplex Nozzle Used with Jet Conveyor. Illustrated....450
Industries to Study New England Power Resources....450
Furnace Design Discussed at A. S. M. E. Meeting....451
Oil Cup Has Non-Removable Cover. Illustrated....452
News Notes....452
Books and Catalogs....454


## Development of Small Water Power with Automatic Equipment

Numerous schemes have been suggested from time to time relating to the complete utilization of our water power resources. While the development of power in large units is one of engineering and economics, the development of the smaller water power stations becomes more a question of purely economical consideration. There are thousands of water power sites in the country which are as yet undeveloped and will in all probability remain undeveloped for many years because the cost of operation is entirely too large in proportion to the output.

Among the plans which have been outlined for the development of the smaller stations is one which apparently merits still further study because it appears practicable. This plan is the use of the automatic hydroelectric station in order to reduce the cost of operation. With the use of such stations, it is entirely feasible to tie together numbers of small plants on one river and so to regulate the automatic operation that full advantage can be taken of storage conditions and at the same time keep the operating force down to the absolute minimum. In fact, the operating force would consist mainly of an inspection crew.

In this issue is presented an article on an automatic station which has recently been placed in operation by the New England Power Co. up on the Deerfield River in Vermont. In comparison with the size of the system, this station is comparatively insignificant; but since some 5000 hp. was available at the site, it was thought that it could be taken advantage of through the use of an automatic station and at the same time reduce the cost of operation.

Probably this development of automatic electrical equipment, including both sub-stations and generating stations, is one of the most important steps forward which has been taken in electrical and hydraulic engineering for the past decade. The increasing success of installations of this type would seem to warrant the prediction that the ultimate development of our small water powers will be largely effected by such engineering.

## Special Turbine Makes Heat Balance Possible

An industrial power plant which undertakes to produce heat and power economically will often be confronted with a complication of variables in the demand placed upon it. It may be a variation in the water power available, a wide variation in power demands, the intermittent demand for large quantities of low pressure steam and hot water, or the demand for power at any given time may not correspond with the amount of low pressure steam required at that time. A combination of these variables may make it very difficult to maintain a heat balance by the use of a non-condensing turbine alone or with one non-condensing turbine and one condensing turbine.

It was a combination of these variables which confronted the engineers of the Norwich, Conn., plant of the U. S. Finishing Co. These engineers found it necessary to install two non-condensing turbine units and one combined mixed flow and bleeder unit. By means of this latter unit, it is possible automatically to maintain a heat balance through a wide variation in power and heat demand. A description of this installation will be found in this issue.

## High Speed Indicator Development

It has become as essential to study engine cycles at high rotative speeds as at the speeds ordinarily found in steam engine practice. In the gas engine, it is not uncommon to meet with speeds of 2000 r.p.m. and above. This is particularly true of automotive and aircraft engines, and as a result of their rapid development great stress has been laid upon the desirability of developing indicators suitable for high speed investigation.

For speeds up to 500 or 600 r.p.m., the ordinary type of indicator has been found suitable provided that the weight of all moving parts was reduced to a minimum and that all lost motion was eliminated. For the higher speeds, numerous factors have had to be considered with the result that the high speed indicators developed so far are of an extremely interesting design and construction. It is claimed that with these instruments it is possible to indicate successfully at a speed of 10,000 r.p.m.

British engineers have recently revived interest in this work with the result that they have developed the three instruments described in this issue.

## Oil Engines Require Intelligent Care

It has been unfortunate, perhaps, that in the early days of oil engine development the engines were sometimes sold and installed with the viewpoint that their operation required no particularly skilled intelligence. As a matter of fact, this was not the case, nor is it the case of any type of prime mover which may be placed in the power plant. For the operation of such equipment, brains are required.

As a result of this early and possibly mistaken sales policy, oil engines in some cases fell down on the job. The method of operation was not correct from an engineering standpoint. Engines were overloaded and overheated, run without sufficient lubricating oil and all manner of serious errors were made in connection with the method of handling such equipment.

Since that time, most manufacturers of this type of equipment have realized that the operator must have a definite training and be just as intelligent as operators of other types of prime movers. This policy, together with the many improvements which have been made in oil engines during the past few years, has practically erased the prejudices which were then formed. The oil engine today is back where it belongs as a type of prime mover which will give excellent service if properly applied, installed and operated.

## Off Duty

Out in southern California, on the sunny slopes of the Sierras not far from Pasadena there stands a wonderful workshop—a workshop in which the toilers have little knowledge of the meaning of the expression "Off Duty." These toilers, are perpetually "On Duty" investigating and unravelling the secrets and the mysteries of the universe. They are the frontiersmen of civilization, out to conquer the unknown, and always in search of truth wherever it leads. Night after night, they venture forth over the universes quadrillions of miles, as hunters in the skies to bring back fresh stellar truths to the earth. Day after day, they penetrate the spacious depths of the atom and bring back wonderful accounts of the forces and all pervading law to be found there. By choice they have dedicated all their waking hours to the ever widening tasks before them—not in any sense of self sacrifice or penance, but simply because of their whole hearted interest in their work and the love of it.

Although scarcely a year old, this workshop, otherwise known as the Norman Bridge Laboratory of Physics of the California Institute of Technology, is already famous—not so much for what it has accomplished as for what those connected with it have accomplished, and for what is expected of it.

This laboratory was presented to the California Institute by Norman Bridge and together with the Gates Laboratory of Chemistry is organized for the joint investigation of the constitution of matter and the nature of radiation. For ages, since the dawn of human thought, in fact, minds have been speculating upon the constitution of matter. What is matter?

Matter occurs in nature under the widest variety of compositions and forms. The physicist who approaches this complex problem by the simplest and most direct route deals with chemical elements and evolves powerful methods of research which enable him to penetrate into the very core of the atom. By observing the action of the terrific forces in the atom upon individual electrons, he is able to visualize the structure of the atom and to learn more of its properties.

The chemist, on the other hand, deals with more complex forms of matter. He is concerned primarily with the union of atoms into molecules and combinations of molecules.

Working in close co-ordination with the physicist and the chemist, is the astro-physicist who by means of his powerful telescopes and spectroscopic equipment is enabled to penetrate the depths of the stellar universe, observes matter on a vast scale under conditions often transcending anything attainable on earth. In the vast cosmic laboratory of nature he studies matter in its most complex forms as well as on an immense scale.

In the establishment of the Norman Bridge Laboratory at Pasadena, the chemist, the physicist and the astrophysicist were brought together in a single center for the investigation of the constitution of matter. This new laboratory with its powerful instruments and adjuncts including a high tension laboratory containing a million volt transformer is a fitting companion to the Gates Laboratory of Chemistry which was already located at Pasadena. Here also, the Mt. Wilson observatory with the most powerful telescope in the world and its incomparable instrument shops in Pasadena provide for astrophysical research. As Dr. Hale, director of the Mt. Wilson Observatory, stated, this was the logical place for the great scientific school of the future. The Norman Bridge Laboratory not only belonged here because of the excellent climatic and geological conditions, but it would be a wholesome neighbor for the famous Mt. Wilson Observatory.

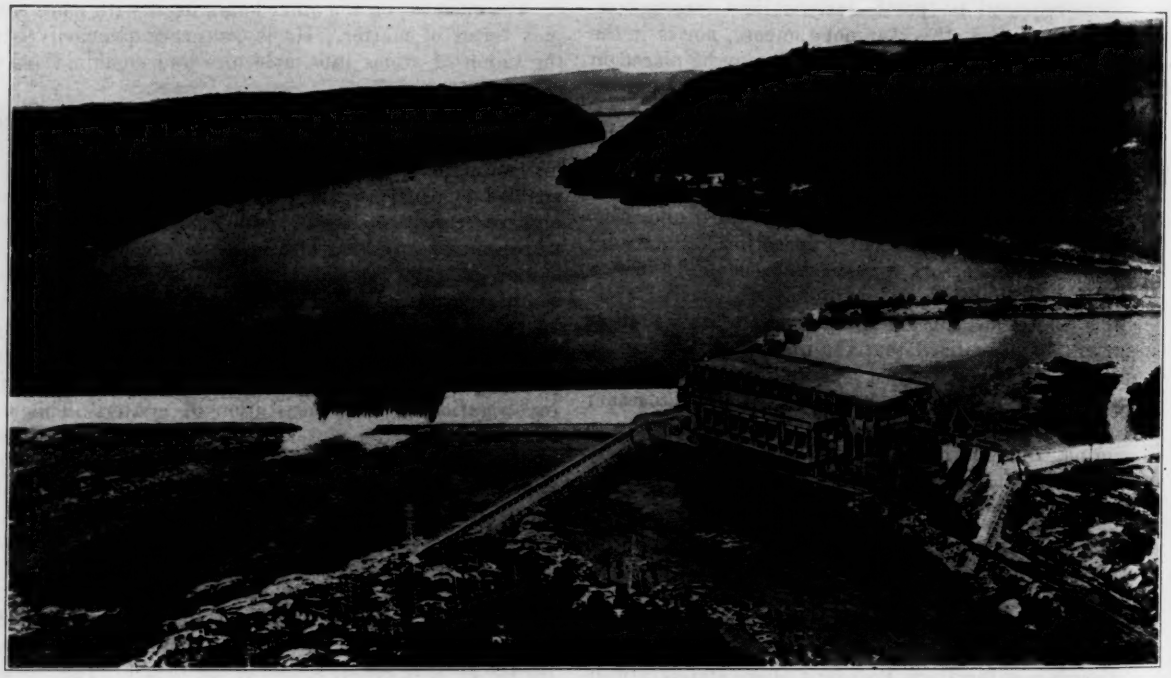
To great scientific centers such as this, then, we may look for some of the answers to the greatest questions of the age. They may not be answered immediately, indeed some may never be answered, but until it is finally demonstrated conclusively that they cannot be answered, our men of science in the great centers of scientific activity throughout the world will leave no stone unturned in their efforts to solve them.

XUM

# Possibilities of Water Power for New York City

NEW YORK ENGINEERS NOT ENTIRELY CONVINCED AS TO THE PRACTICABILITY OF USING HYDROELECTRIC POWER

GOVERNORS of New York and Pennsylvania were unable to accept an invitation extended to them by the Metropolitan Sections of the four national engineering societies to attend a joint meeting of these organizations at the Engineering Societies' Building, New York City, on Mar. 21; but their absence did not lessen the interest shown by a great number of engineers who gathered to listen to the discussion of "Hydroelectric Power for New York," the timely subject upon which a symposium had been arranged for this occasion.



HOLTWOOD STATION ON THE SUSQUEHANNA RIVER

As presiding officer, Calvert W. Townley, chairman of the New York Section of the A. I. E. E., emphasized the importance of the future power needs of the city, and introduced Col. F. W. Scheidenhelm, who gave the "Co-ordinating Statement of the Problem." He pointed out that examination and appraisal are necessary for every hydroelectric development, but that, while the present reliance of the metropolitan district is upon steam-electric power, it must ultimately look to the utilization of the inexhaustible stream-flow at available sources. The present obstacles to such development Col. Scheidenhelm summarized as follows:

Limited appreciation of availability; uncertainty or disagreement as to relative cost; doubt as to quality of service; legal difficulties; lack of fixed, continuous policy on part of political units concerned.

He drew attention to the relation between installed capacity and energy output, and classified the former as (1) Hydro-capacity which is a reliable substitute for steam capacity, and (2) All remaining hydro-capacity, and the latter as (a) Portion of delivered hydro-output otherwise necessarily generated by steam-electric capacity, for which Class 1 hydro-capacity serves as substitute, and (b) All remaining hydro-output. Low daily and weekly load factors occur at periods of low stream flow, and low water supply and large demand may be coincident. The Niagara and St. Lawrence rivers are not so readily available as interior streams. As examples of over-development, were cited the Holtwood plant on the Susquehanna, and the Salmon River plant of the

Niagara, Lockport & Ontario Power Co. The former is employed in connection with steam-electric plants, the latter as a supplement to the Niagara power; both operate at very low load factors during dry periods. Stress was laid on the reliability of the low-speed hydraulic equipment vs. the high-speed steam turbine, although transmission lines are longer for the hydraulic plant. As advantages incident to the utilization of water power were mentioned:

Financial economies, due to higher fixed charges on steam plants, railroad congestion, and coal mining troubles. Continuous service from double source of supply. Market on both sides the Hudson.

On the subject, "An Approximation of Available Water Power and Cost of Delivery," W. S. Murray, former chairman of the Super-power Survey, estimated the probable available water power for the city by the year 1930 as about 30 per cent of the total power requirements at that date. Of the interior streams, he estimated that the Susquehanna, a stream of intermittent flow, would be good for 185,000 kw. by 1930, while the Delaware and the Hudson, both of which permit storage of water for dry periods, would develop 350,000 kw. and 150,000 kw. respectively. The Niagara and St. Lawrence water powers lie closer to the metropolitan load center than to those of Boston and Philadelphia, and power from these sources would probably be cheaper than that derived from the interior streams. Within 5 yr., 500,000 kw. of combined steam- and hydro-electric power from sources within 100 mi. could be delivered to the outskirts of the metropolitan district at a cost not exceeding seven mils per kilowatt-hour. An interesting feature of Mr. Murray's talk was related to the progress toward realization of the superpower plan. Stations of superpower dimensions are now in operation at Hell Gate and at Hartford; others are in progress at Brooklyn, at Devon near New Haven, and at Weymouth near Boston; another near Newark, N. J., is being designed; and the first of the three plants projected for the anthracite region, to be located on the Susquehanna River, is under consideration.

### Viewpoint of New York Edison Co.

George A. Orrok, consulting engineer of the New York Edison and affiliated companies, spoke on "Requirements of Service and Evaluation of Hydro Power." While admitting the probable recourse to hydraulic power, he laid stress upon the difficulties to be overcome, the inflexible standards of service adopted by the metropolitan utilities, and what he referred to as the speculative character of the water power business, which he compared to farming in its reliance upon changeable natural phenomena. He also emphasized the fact that by 1930 not more than one-third the power required could be obtained from water power, and stated that with coal at $8 a T. a price of six mils at the boundary of the district would be the maximum attractive figure.

"Quality of Hydro Service" was discussed by F. A. Allner, general superintendent, Pennsylvania Water & Power Co., in charge of the 110,000-kw. Holtwood development on the Susquehanna River, an airplane view of which is shown in the illustration. An addition of 40,000 kw. which is under way will bring this plant up to its maximum of 150,000 kw. Mr. Allner gave the following list of standards used for classification of trouble on the system: Total loss of load, if only for 1 sec.: total interruption. Partial loss of load, if traceable on station instruments: partial interruption. Irregularities in voltage and frequency exceeding 4 per cent in voltage or 2 cycle in frequency, even though not traceable on graphic wattmeters: disturbances.

Very little trouble, he said, had been encountered with the hydraulic plant, and transmission troubles had dwindled after the first year (1911), due largely to use of the Nicholson arc extinguisher; distribution troubles, on the contrary, had increased in the last 5 yr. period as compared with the preceding 5 yr. Operation at this plant was described and illustrated with lantern slides, and a discussion of conditions likely to be met in a large co-ordinated system for supplying metropolitan needs and of the general advantages of hydro-electric over steam-electric plants followed. The system would include base load, peak load, and run of river developments, provision for minimum flow being a question of economics and not affecting service in a proper scheme of development.

While the hydraulic plant is not so easily altered to correct unsatisfactory conditions, it is inherently more reliable than the complicated steam turbine plant. There are also other advantages, one of which is the speed with which units can be put into service from a standstill to meet unexpected conditions such as thunderstorm loads. A hydro-turbine may be put on line from a standstill in less than half a minute, and the operation can be completed by the switchboard operator without other attendant.

### Reliability of Transmission Systems

Lorin E. Imlay, consulting engineer for the Niagara Falls Power Company, spoke on "Reliability of Long Distance Transmission." He gave a rapid resume of development in the art of electrical transmission, and maintained that it has now reached a stage of reliability equal to that of steam plants. The example of Buffalo and of several Canadian cities was cited to illustrate the reliability of long distance transmission.

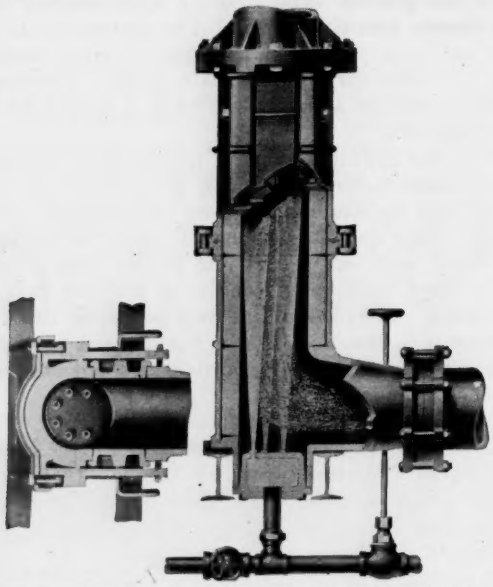
In discussing the papers of the meeting, John P. Hogan, consulting engineer with William Barclay Parsons, referred to the large contingent benefits from the superpower plan. In developing the water powers, each stream should be taken by itself and a unified progressive development made. Interior streams with storage capacity are most available for the metropolitan area; from them, practically continuous power may be obtained at high load factor. Continuous power with low peaks but high output is available from the Niagara and the St. Lawrence. Steam-electric power from New York City could also be made use of at distant points.

W. S. Finlay, Jr., vice-president of the American Water Works & Electric Co., stated that the hydroelectric power must be considered within 35 yr. He asked whether we would continue to demand the present continuity of service, and to pay for it, and said that we face a period of education as to what we want for our dollar. At all events, we must continue to strive for the best efficiency from steam, since 30 per cent of requirements is the best to be expected from water power by 1930.

Development of the Niagara and St. Lawrence rivers was the theme of T. Kennard Thomson, consulting engineer, who confined his remarks to an outline of projects prepared by him for utilizing the possibilities of these waterways.

# Multiplex Nozzle Used With Jet Conveyor

ONE improvement recently made by the M. H. Detrick Co., Chicago, in its steam jet ash conveyor is the use of a multiplex nozzle instead of the single nozzle system formerly used. As will be noted from the accompanying illustration, this arrangement consists of a manifold casing into which six small nozzles are screwed on a diameter about 2 in. less than the internal diameter of the pipe. These nozzles are so arranged that the front portion of the circle is left open to allow an entrance for ash and air. The combined area of all six



MULTIPLE NOZZLES TEND TO KEEP LAYER OF STEAM NEXT TO WEARING SURFACES

nozzles is the same as would be the area of the single nozzle if only one were used.

It is said that this design reduces the abrasion on the wearing backs of the elbows because there is a sheet of steam between the ashes and the wearing backs. Since the nozzles are arranged in a circular shape, a funnel of steam is obtained, providing cyclonic action which creates a greater suction with a given amount of steam. Tests have shown that 10 per cent greater suction is obtained with six nozzles whose total area equals a ⅝-in. diameter nozzle than with a single ⅝-in. nozzle.

# Industries to Study New England Power Resources

WITH power costs in New England far higher than those in any other section of the country, with coal and fuel oil not only costly but at times exceedingly difficult to secure, particularly during such winter months as have recently passed in New England, with the possibility of obtaining current from Canada temporarily, at least, out of the question owing to governmental restrictions, a situation confronts the industries of New England which may soon become serious.

At a conference held at Boston recently, the Associated Industries of Massachusetts, therefore, thoroughly discussed the power possibilities of New England and as a result have appointed a Fact Finding or Survey Committee, which is to make a complete survey of power conditions and possibilities in New England. For the initial part of this survey, the Associated Industries expect to spend about $50,000.

It will be the principal aim of this survey to find out what the possibilities of developing hydroelectric power plants are, with a general plan of determining how much power can be so generated and the probable reduction in costs of obtaining such power over the present widely scattered methods. To the New England industries, cost of power is becoming more and more a serious problem each year when compared with costs in other sections of the country. In the South, for example, power is so small an item that oftentimes lights are left burning day and night while in New England the most rigid economy must be practiced at all times. The survey may reveal possibilities of power production, by united effort, which have been overlooked or deemed impractical for individual development, so that not only may current be secured at lower figures for the industries of the section, but may also be supplied to power and public utility companies at greatly reduced figures.

There is an abundance of water power available for hydroelectric development, but at the present time the units making up the general development are widely scattered. It may be determined by the survey that these can be brought into harmony for greater production for the whole state.

More than a hundred of the largest power users of Massachusetts are back of the proposed survey.

The Fact Finding Committee appointed is composed of Charles T. Main of Boston, industrial engineer; Dugald C. Jackson, head of the department of electrical engineering of the Massachusetts Institute of Technology; Henry I. Harriman, president of the New England Power Co.; B. Preston Clarke, vice-president of the Plymouth Cordage Co., and George L. Finch, engineering superintendent of the Hood Rubber Co.

It is expected that the survey will include the kinds and amounts of power now used in New England, the cost of each and the increase in cost during the past ten years; the available new sources of power, both within and outside the borders of New England; the probable demand for such power; the increase in demand for power during the past ten years, and the cost of supplying it to indsutries and public utilities in New England.

At the first meeting of the Fact Finding Committee, held March 27, it was determined that the project will be mapped out and work laid out before the survey is actually started. It is expected that the survey will take several months to complete. The committee will then report back to the Associated Industries for further action.

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ANNOUNCEMENT that the Potomac Electric Power Co. has awarded a contract to Stone & Webster, of Boston, for the construction of an annex to the main power plant at Bennings, Washington, D. C., was made recently by General Superintendent L. E. Sinclair of the power company. He said that bids and estimates place the expenditure at $1,800,000 for this new 20,000-kw. turbine-generator unit.

# Furnace Design Covered at A. S. M. E. Meeting

PRESENT tendencies in the design of boiler furnaces were discussed by Edwin B. Ricketts, assistant to the Chief Operating Engineer of the New York Edison Co., in a paper read before the Metropolitan section of the A. S. M. E. on Mar. 27. The subject was treated under two general heads, (1) furnace volumes, and (2) construction of furnace walls.

Under the first head, the speaker admitted his inability to justify the expense involved in the large furnace volumes of the present day, and said that an exhaustive study for the Stokers and Furnaces Section of the Prime Movers Committee Report had failed to establish the relation between furnace volume and boiler efficiency. In a review of facts brought out by this investigation, tables were presented, showing furnace volume per rated horsepower in recently constructed central stations and rate of firing per unit of furnace volume at efficiencies of about 80 per cent, for various systems of firing. The more important variables bearing upon furnace volume required for complete combustion were listed as (1) physical state and chemical composition of fuel, (2) type of fuel burning equipment employed, and (3) shape of combustion chamber and means provided for mixing fuel and air in the furnace. Each of these variables was briefly discussed. From the standpoint of chemical and physical properties, oil, low volatile lump fuels, and high volatile solid fuels were shown to require successively large furnace volumes. A similar series for types of equipment is formed by mechanical oil burners, underfeed stokers, chain grate stokers, and pulverized fuel systems. In the case of chain grate stokers, a more or less elaborate system of arches is required for mixing the gases from different sections of the fuel bed. For pulverized fuels, a number of systems have been proposed for mixing in the burners, but none of these has yet reached a commercial stage of development.

A perfect boiler wall was defined as one which under service conditions would be impervious to flow of gas, air, or heat units and would neither crack, spall or soften nor be injured by molten slag. Refractories were considered in relation to these requirements, and it was shown for practical considerations the main reliance must be placed on fire clay. Present costs of fuel, labor, and equipment enforce new economies which increase the severity of service conditions for refractories as follows: (1) By increase in rate of operation. (2) By increase in insulation against heat and leakage. (3) By reducing excess air and preheating air for combustion.

### Temperature Gradients Considered

Temperature gradients through boiler walls and causes of wall failures were next considered. Erosion by molten ash was found responsible for more wall failures than all other causes combined. The effect of this is worst when pulverized coal or forced draft stoker flame strikes a wall carrying with it and embedding particles of molten ash which weaken the resistance of the wall. The manner in which ash erosion takes place and the depth of penetration of dangerous temperatures into furnace walls were particularly treated. Under the conditions imposed, it was shown that fire clay brick will not stand up unless special means are provided, and reference was made to air and water cooling of furnace walls. In Mr. Ricketts' opinion, the present tendency is toward having the combustion space entirely surrounded by water and steam cooling surfaces.

This paper called forth an unusual amount of interesting discussion. V. M. Frost, of the Public Service Corporation of New Jersey, cited the example of a Pittsburgh plant where clinkering was greatly reduced by increasing the height of boiler setting from 18 ft. to 22 ft. High furnace setting with air cooled walls appeared to him to meet the problem of making walls that will stand up with the brick that is available.

Nobody has designed a first class furnace for present day capacities, according to J. H. Lawrence, of T. E. Murray, Inc. At Hell Gate, trouble was encountered with erosion just above the stoker bed. Redesign of stokers has helped this situation—using high side wall tuyeres in some cases. With a 13-ft. setting in a Middle Western plant, the front wall only stayed up for 30 days. This was remedied by a change from vertical to inclined baffling at the first pass, giving more room for the gases leaving the furnace, and increasing the life of the front wall to a year. Emphasizing the desirability of removing strain from the furnace walls, Mr. Lawrence mentioned the construction at Hell Gate, where the side walls are divided into vertical panels about 4 ft. 6 in. long. When the furnace is cold, cracks appear from top to bottom between panels; these are closed when the furnace is heated.

Erosion of front walls at Hell Gate due to overhang of about 8 in. above the tuyeres was cited by W. C. Drake of the Furnace Engineering Co. This was overcome by designing a coal cap.

E. S. Cooley of the International Paper Co. mentioned a case where special inclined baffling had obviated the necessity for increasing the height of boiler setting.

Experience at the Springdale Station was briefly described by J. E. Bell of the West Penn Power Co. Three types of setting—14 ft., 16 ft., and 22 ft. are employed there. The last carries a load of 275 per cent of rating while on line. The side walls are graded in thickness from 32 in. at the bottom to 22 in. at the top. Clinker which collects on bottom rows of tubes is taken care of by wetting down with a hose several times while the boiler is out of service. On starting, it is found to be easily removable with a suitable tool. The speaker emphasized the importance of stream line flow for the gases, without choking.

Mr. Spence, of McClellan & Junkersfeld, said that furnace volume data must be applied with careful judgment; it is essential that combustion be complete before the gases strike the tubes. With short flame anthracite, the American Sugar Co. uses 2 cu. ft. per hp., while at Calumet with long flame Illinois coal the ratio is 4.75 cu. ft. per hp. At Cahokia, where the ash fuses at 2000 deg. F. and fuel is very high in both sulphur and iron, a difficult problem is encountered. Air cooled walls will apparently give the longest life. In two Middle Western plants, repair of side walls by shooting ganister with a cement gun has proved satisfactory.

When you start reducing temperature, you reduce efficiency, said T. B. Stillman, of the Babcock & Wilcox Co. He thought that a brick must be developed which would hold the weight and stand the temperatures required under present conditions.

H. D. Savage, of the Combustion Engineering Corporation, said that large furnaces make little difference, but advocated preheating of air and reduction of radiation losses. He also called attention to the value of blocks, which can be made just as true as smaller brick.

Simplicity of the fundamentals of combustion and difficulty of their application were emphasized by E. Y. Sayer, of the Sayer Engineering Corporation. First among fundamentals, he placed the distinction between heat and temperature, the latter being analogous to voltage, the former to amperage. We reduce air to the minimum for complete combustion in order to cut down stack losses. Sufficient time must be allowed for contact between oxygen and combustible; 3000 deg. F. is about the limit for good fire brick. If this is too high, take away from the brick its temperature, which depends on how fast it gets heat and how fast heat is removed from it.

## Oil Cup Has Non-Removable Cover

AN INTERESTING feature of a small pressed steel oil cup which has recently been developed is in the design of the cover. The cap is pressed on to the shell and

COVER MAY BE ROTATED BUT CAN NOT BE TAKEN OFF

while it can be rotated to expose the hole for filling, it can not be removed. This assures that the cup will be kept free from dirt, as it is always closed. Excessive vibration has no effect on the cap, as it is not possible for it to loosen up or to rattle. Oil is fed to the point to be lubricated by means of a felt wick extending from just under the cover to the bottom of the pipe connection.

Cups of this type are made by the Hunter Pressed Steel Co., of Lansdale, Pa.

## News Notes

AT THE MEETING of the Board of Directors of the American Institute of Electrical Engineers held in New York, Mar. 16, the Committee of Tellers reported that Harris J. Ryan, Stanford University, Calif., had been nominated for president of the institute.

MARCH 31 marked the close of work for the State Fuel Administration in New York, as the emergency which called it into being was past. The organization was created last September, when Governor Miller appointed William H. Woodin administrator. It has had to do with regulation of supply for domestic as well as power purposes. Under Governor Smith, Mr. Woodin was succeeded in January by General Goethals, whose capacity for organization has been felt in this as in other activities which have made his name familiar.

IMPORTANT PAPERS covering the subject of electricity in industry will be presented and discussed at the Spring Convention of the American Institute of Electrical Engineers to be held in the William Penn Hotel, Pittsburgh, April 24 to 26, inclusive. These industrial engineering topics will be discussed at a special session of the convention Wednesday morning, April 25, held under the direction of the Electro-Chemistry and Electro-Metallurgy Committee, of which J. L. McK. Yardley, general engineer of the Westinghouse Electric & Manufacturing Co., is chairman.

H. V. PETERSON, associated for a number of years with the De Laval Steam Turbine Co., has recently been appointed district manager, with headquarters in Chicago.

ANNOUNCEMENT is made that the exclusive license to manufacture and sell the Mitchell electric vibrating screen has been acquired by the C. W. Hunt Co., Inc., New York City, designers and manufacturers of material handling equipment.

DONALD DES GRANGES, formerly with Cram & Ferguson, the Boston architects, has joined the organization of Stone & Webster, Inc., of Boston as engineer in the Structural Division. During the war, Mr. des Granges was engaged in architectural work in France on the development of the port of St. Nazaire and other A. E. F. operations.

A. H. NICKERSON, who, since 1904, has been with the American Agricultural Chemical Co., has resigned to accept a position with Stone & Webster, Inc., in the Mechanical Division. Mr. Nickerson started with the former company as Chief Engineer, holding that position until 1921 when he was made Manager of the manufacturing department.

MATHIESON ALKALI WORKS at Saltville, Va., has decided to use pulverized coal as a fuel in its plant and to that end has contracted with the Fuller Engineering Co. for the design and installation of a complete coal pulverizing plant, which will comprise Fuller indirect fired driers, Fuller mills, Fuller-Kinyon transport system and Fuller burners and feeders.

SCRIBNER K. PAGE, who has long been identified with the power plant field and is thoroughly familiar with its problems, formerly chief engineer for Schrafft's, the candy manufacturers, and past president of the Massachusetts N. A. S. E., has been appointed as New England representative of the Bundy Steam Trap Co., Nashua, N. H., and will make his headquarters at the Boston office.

CLIFFORD F. MESSINGER for the past 3 yr. general sales manager of the Chain Belt Co., Milwaukee, has been elected second vice president, according to an announcement just made by the company. Mr. Messinger was graduated from the Sheffield Scientific School, Yale University, in 1911 and entered the employ of the Chain Belt Co. the same year. He has at various times oc-

cupied the positions of advertising manager, manager of concrete mixer sales and general sales manager. He is also a director of the Chain Belt Co. and a director of the Interstate Drop Forge Co., Milwaukee.

DAVID N. GRAFFAM, a modest man who in recent years has held the position of caretaker of all of the clocks owned by the city of Providence, R. I., died in that city March 19, almost unknown except to a small circle of friends. David N. Graffam was the inventor of the modern waterwheel, now used in general in turbines, fan blowers and similar inventions of which it is the basic principle. The invention became common property. He was a watch and clock maker and inherited a sawmill with an old fashioned water wheel. He experimented with that wheel until the modern type was evolved. He had continued his trade of clock repairer, from which he gained his livelihood, up to within a short time of his death. He was 96 yr. old.

E. J. MORGAN is now associated with the De Laval Steam Turbine Co. in its Chicago office. Mr. Morgan was formerly in the Chicago office of the Worthington Pump and Machinery Corp.

APPALACHIAN POWER CO., Glen Lynn, Va., is increasing its boiler plant capacity in order to keep up with the demand for electricity by the coal mines. Four Westinghouse underfeed stokers will fire four 1232-hp. B. & W. boilers with Pocohontas coal. The installation will include power operated dump grates, extension sidewall tuyeres, turbines will drive the stokers as well as the fans.

INCREASED DEMAND for electric power on electric light and railway companies is reflected in the construction program of the American Railway Company at their Kenova, W. Va., plant of the Consolidated Light, Heat & Power Co. Here four new 1000-hp. B. & W. boilers will be fired by four new model multiple retort Westinghouse underfeed stokers. Steam dumping mechanisms and extension sidewall tuyeres are included in the stoking equipment of this power plant extension. West Virginia bituminous coal will be used.

L. H. HURD and associates will build a large modern power plant in Wichita, Kansas, to supply electrical power to the plants of the Red Star Mill & Elevator Co. The plant probably will be ready for operation by the first of October. The cost will be about $100,000. The contract for the installation of the plant was let to McIntosh & Seymour Co., of Auburn, N. Y., by its western representatives, S. A. Hadley of Kansas City. Engines for the plant will be specially built. They will be Diesel engines of 750 hp. each.

AN ACT to incorporate the Kennebec Reservoir Co. in Maine has been passed over the veto of Governor Baxter by the Legislature by a vote of 121 to 25 in the house and a vote of equal proportions in the Senate. Incorporation of the company will now go forward and it is probable that active work by the company will commence within a month. The company proposes to construct an immense reservoir in the Dead River region to regulate the water supply to the mills along the Kennebec River and to supply power and light to some of the communities along the river, an account of which has already been published in Power Plant Engineering.

GREAT WESTERN POWER CO. of California plans to begin construction of the third unit of its big Caribou plant on the north fork of the Feather River at once. The two units already constructed have a generating capacity of 44,000 kw. of electricity. The third unit will add an additional 22,000 kw. and will fill the Caribou power house to capacity. The new construction will require an expenditure of $1,500,000. The transmission line, tunnel, and pipe line are already completed, the addition of a third unit requiring only the installation of a generator, a transformer and some subsidiary work.

CENTRAL INDIANA POWER CO., which controls and operates a number of central station properties in Indiana, has recently organized a new subsidiary company, known as the Indiana Electric Corporation, for the purpose of building a new 40,000-kw. power plant at Maxsville, Ind., a short distance from Terre Haute. This new station is to be used as a base load station to the other plants of the Central Indiana Power Co. The station will ultimately have a capacity of 100,000 kw., generated by five 20,000-kw. turbines. Two of the turbines have already been ordered from the Westinghouse Electric & Manufacturing Co. and are now in course of construction.

THE EDISON ELECTRIC ILLUMINATING CO. of Boston, Mass., has acquired a tract of land on the waterfront of Boston Harbor in the town of Weymouth, 12 mi. south of Boston, of 60 acres upon which it is to commence at once the construction of its main power generating plant. The site was at one time known as Downers' Landing and was a famous picnic ground. The plant, when completed, will have a capacity of 400,000 hp. and a coal storage capacity of 300,000 T. This will give a capacity for Greater Boston of twice as much current as was consumed on an average during December last. Its coal storage capacity will carry a supply sufficient for 170 days.

COMPLETION of work on state hydroelectric power plants under construction at Vischers Ferry and Crescent Dam was urged in a message of Governor Smith to the New York State Legislature on Mar. 19. The combined capacity of the plants will be 16,000 hp., which will be available for approximately 60 per cent of the time. An appropriation of $710,000 is required to finish the work started under Governor Miller with an appropriation of $1,000,000. Governor Smith further advocated a change in the law, to permit the Superintendent of Public Works, the State Engineer, and the Attorney General to negotiate with municipalities for the sale of this power and the supply of auxiliary power to supplement it at times of low water.

THREE COMPANIES will jointly erect a new power plant at Fall River, Mass., to cost $5,500,000. The companies are the Fall River Electric Light Co., Edison Illuminating Co., of Brockton, Mass., and the Blackstone Valley Gas and Electric Light Co. The new plant is north of the present plant on Hathaway St. and will front on the harbor. Current and power will be generated for Fall River, Brockton, and the communities in the Blackstone Valley and it is believed that the joint operation of the plant will lower costs of production so that reductions may be made in existing rates to consumers. The three companies will jointly own and

control the plant. The present plant will be used as an auxiliary when the new station is completed.

COMPLETION of the Holtwood power station, on the Susquehanna River, of the Pennsylvania Water & Power Co., delayed almost 10 yr. by the war, is finally to be brought about. A contract has been given the I. P. Morris department of the William Cramp & Sons' Ship & Engine Building Co. for the remaining hydraulic machinery needed, consisting of two 20,000 hp. Francis turbines of the I. P. Morris design. The addition of this equipment will bring the station up from 110,000 to 150,000 hp. capacity, for which it was originally planned.

At present the hydraulic equipment consists of eight turbines, all of I. P. Morris design and construction; the two new wheels, however, will not only be much larger and more powerful than any of the older ones, but the delay has enabled the Cramp Co. to embody in them a number of the latest improvements, evolved since the original installation was made, in design of draft tubes, etc., which will result in increased efficiency of the station as a whole.

This station operates on an average effective head of 54 ft., the concrete dam being 55 ft. in height and half a mile long. The present battery of generators is of the three-phase, 25-cycle type, with 11,000 v. at the generator terminals. This is stepped up by transformers to 70,000 v. in the long-distance transmission lines.

# Books and Catalogs

MACHINERY FOUNDATIONS AND ERECTION, by Terrell Croft. First edition, 691 pages, 773 illustrations; 5½ by 8, cloth; New York, 1923.

From the first chapter, through the design and installation of foundations, and the erection of machinery, this book treats the subject in a non-mathematical manner, so that a working knowledge of arithmetic is ample whereby machinery foundations may be effectively designed and constructed. This book discusses: the proper proportions for foundations of various types, the selection of the proper type of foundation for a specific purpose, foundation installation and reconstruction, design and construction of foundations for machines and engines of all types, methods of erecting machinery and engines after the foundations have been built, the repair and enlargement of existing foundations. Power plant engineers, works superintendents and millwrights will find in this book a great amount of practical information.

ZEOLITE water softening is the subject of bulletin 509 which is now being distributed by the Graver Corporation of East Chicago, Ind. In taking up this discussion, the chemistry of Zeolite water softening is presented and the mechanical features of the apparatus for using this process are shown.

CONDENSING and non-condensing turbines are described in a bulletin entitled "The Terry Turbine" which has recently been issued by the Terry Steam Turbine Co., Hartford, Conn. A brief history of the steam turbine is presented and the bulletin goes on to show how the Terry turbines are classified according to whether they are to be used for condensing or non-condensing service. Charts are also shown which give a graphic picture of how the energy in the steam is used in condensing, operation, bleeder operation and where the turbine used for condensing and the constructive features of the Terry turbine are described in detail.

CHICAGO Pneumatic Products are covered in a folder which has just been issued by the Chicago Pneumatic Tool Co., of New York City. The entire line of pneumatic hammers, air drills, hoists and compressors are illustrated and briefly described in this folder.

ST. MARY'S OIL ENGINES are covered in a bulletin which has been published by the St. Mary's Oil Engine Co. of St. Charles, Mo. In this engine, fuel oil is admitted by gravity or the pump system and the charge is ignited by the heat of compression. The bulletin shows the details of the engine such as the valves, piston, crank shaft and other such details.

CENTRIFUGAL PUMPS and Centrifugal Pumping Units is the title of a bulletin just published by Allis-Chalmers Mfg. Co., of Milwaukee, Wis. In addition to discussing the complete line of Allis-Chalmers centrifugal pumps, the bulletin also gives considerable general data on pumps of this type such as head capacity tables, friction tables and a discussion of the Cippoletti trapezoidal weir. Photographs of various types of pumping installations are also shown.

OPERATION and construction of the Republic flow meter is the subject of a bulletin O. C. 15 recently published by the Republic Flow Meters Co., of Chicago. In this bulletin the details of this electrically operated flow meter are described and there is also a discussion of the theory of measuring flow of fluids by electricity. Another interesting feature is a chart from which it is possible to figure the sizes of pipe required to secure a certain velocity of steam at varying pressures or the chart may also be used to figure the velocity of steam flowing through a certain size of pipe when the pressure is known.

DE LAVAL Steam Turbine Co., of Trenton, N. J., has issued an interesting leaflet describing the pumping equipment of the new plant of the American Sugar Refining Co., at Baltimore. This immense refinery is the largest in the world. It is situated on a 21-acre tract and comprises 15 separate buildings from one to ten stories in height. Pumping equipment includes pumps ranging in capacity from 50 g.p.m. to 5500 g.p.m., and for heads of from 35 to 193 ft.

SWITCHBOARD PANELS and Supporting Framework is the title of bulletin No. 47,002, issued by the General Electric Co. This bulletin groups switchboard panels under two general classifications, the vertical type and the bench type. Slate and marble are the two materials mentioned as being universally used for switchboard panels. The standard heights vary from 16-in. single section panels mounted on supports 48 to 99 in. high; panels in three sections on supports 99 in. high. All panels have ⅜-in. bevel. The standard supporting framework for panels adopted by the company consists of 1¼-in. wrought iron pipe for the uprights and ¾ or 1¼-in. pipe for tie rods bracing the panel to the floor.

The bulletin contains much useful information for prospective buyers of switchboards.